US006772433B1

(12) **United States Patent**
LaJoie et al.

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(45) **Date of Patent: Aug. 3, 2004**

(54) **INTERACTIVE PROGRAM GUIDE FOR DESIGNATING INFORMATION ON AN INTERACTIVE PROGRAM GUIDE DISPLAY**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/185,179**

(22) Filed: **Nov. 3, 1998**

Related U.S. Application Data

(63) Continuation of application No. 08/802,833, filed on Feb. 19, 1997, now Pat. No. 5,850,218.

(51) **Int. Cl.**[7] **H04N 5/445**; H04N 7/173; G06F 3/00; G06F 13/00

(52) **U.S. Cl.** **725/52**; 725/33; 725/58; 725/104; 345/767; 345/786

(58) **Field of Search** 725/44, 52, 53, 725/38; 345/830, 828, 829, 831, 784, 786

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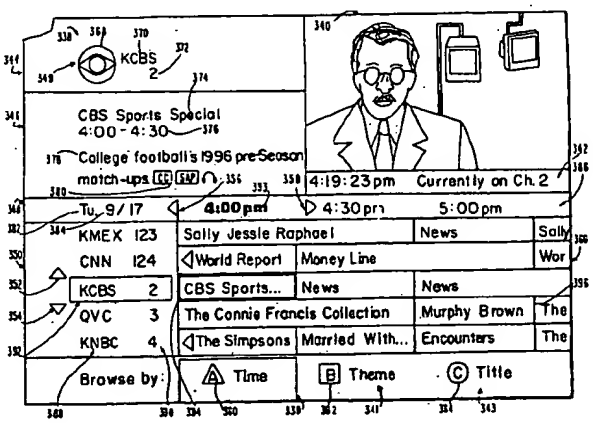
Assistant Examiner—Andrew Y. Koenig
(74) *Attorney, Agent, or Firm*—Fish & Neave; Garry J. Tuma

(57) **ABSTRACT**

A system and method are provided for providing a full service cable television system. The cable system incorporates a digital and analog transmission architecture capable of delivering a high number of high quality television programs, advanced cable services, and online services to a subscriber's home. The cable system comprises a cable headend, at least one fiber transport, at least one distribution hub, at least one hybrid fiber coax plant, and a plurality of set-top terminals. Programs and services are transmitted to the set-top terminals in both digital and analog formats to maintain downward compatibility with existing systems. The set-top terminal incorporates a central processing unit, a unified memory architecture, a memory management unit, communications circuitry, I/O control circuitry, and audio and video output circuitry. Through these components the set-top terminal provides advanced cable services such as a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On-Demand and Video-On-Demand programming, and advanced configuration controls. The set-top terminal also provides online services such as World Wide Web browsing, Internet E-Mail, and Home Shopping.

20 Claims, 35 Drawing Sheets



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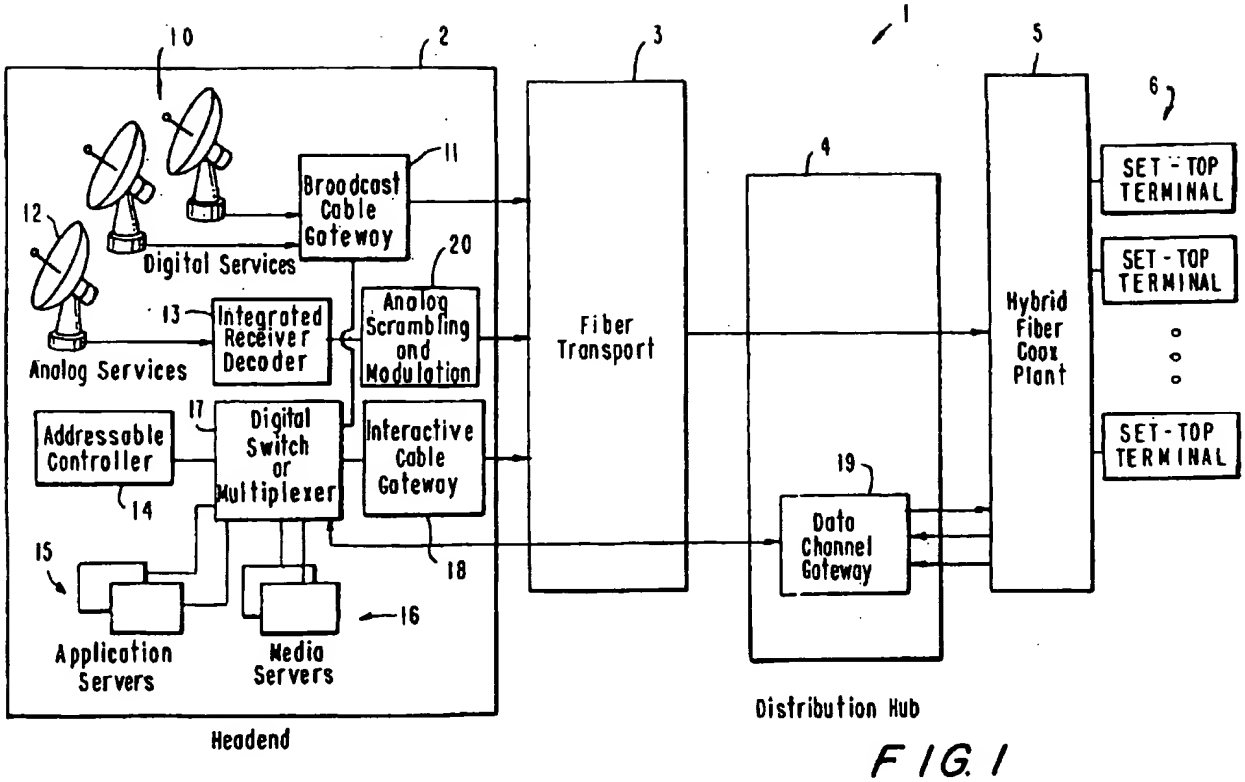
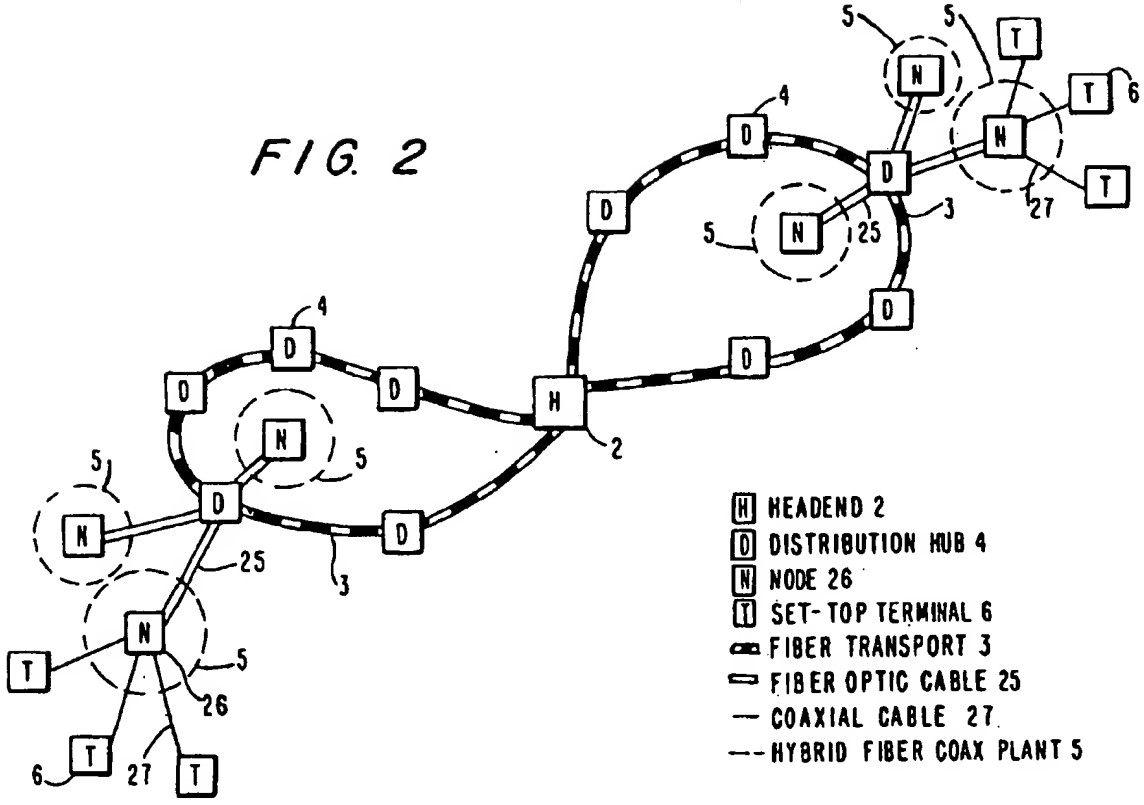

10
2
3
1
5
6
4
11
12
20
13
17
19
14
15
18
16
Broadcast Cable Gateway
Digital Services
Analog Services
Integrated Receiver Decoder
Analog Scrambling and Modulation
Addressable Controller
Digital Switch or Multiplexer
Interactive Cable Gateway
Application Servers
Media Servers
Fiber Transport
Data Channel Gateway
Hybrid Fiber Coax Plant
SET-TOP TERMINAL
SET-TOP TERMINAL
SET-TOP TERMINAL
Headend
Distribution Hub

FIG. 1

FIG. 2


H HEADEND 2
D DISTRIBUTION HUB 4
N NODE 26
T SET-TOP TERMINAL 6
FIBER TRANSPORT 3
FIBER OPTIC CABLE 25
COAXIAL CABLE 27
HYBRID FIBER COAX PLANT 5

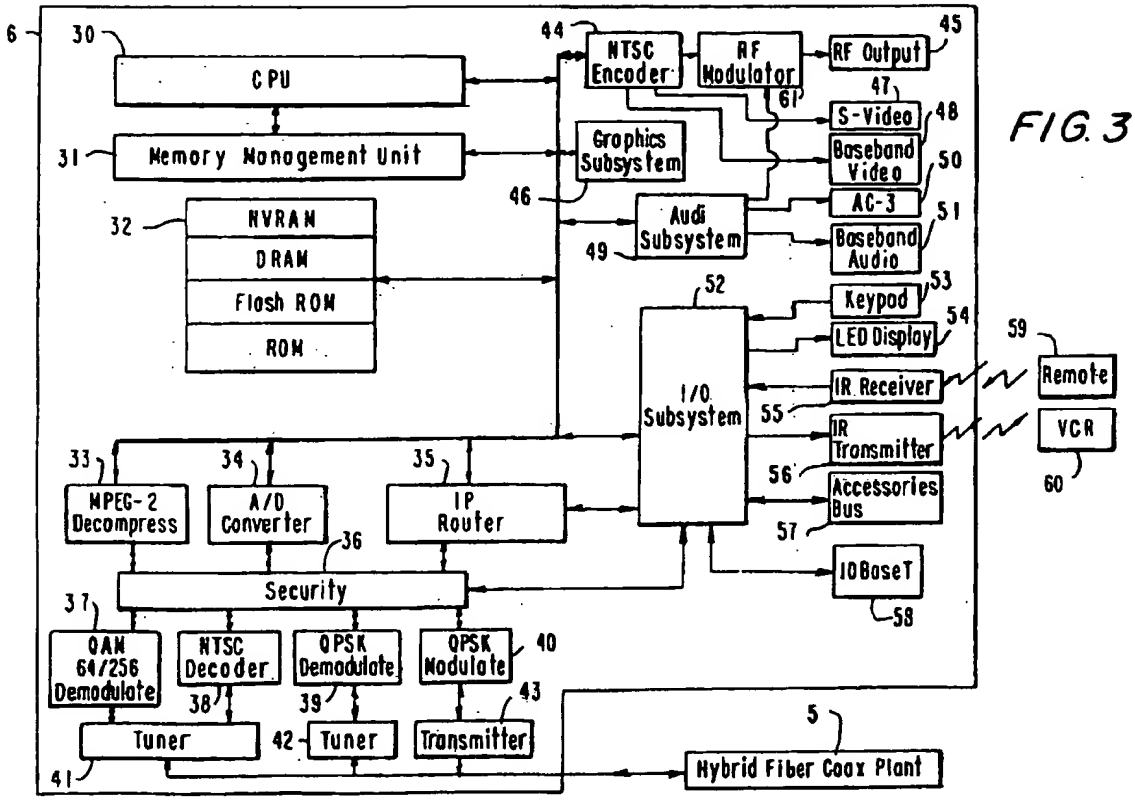
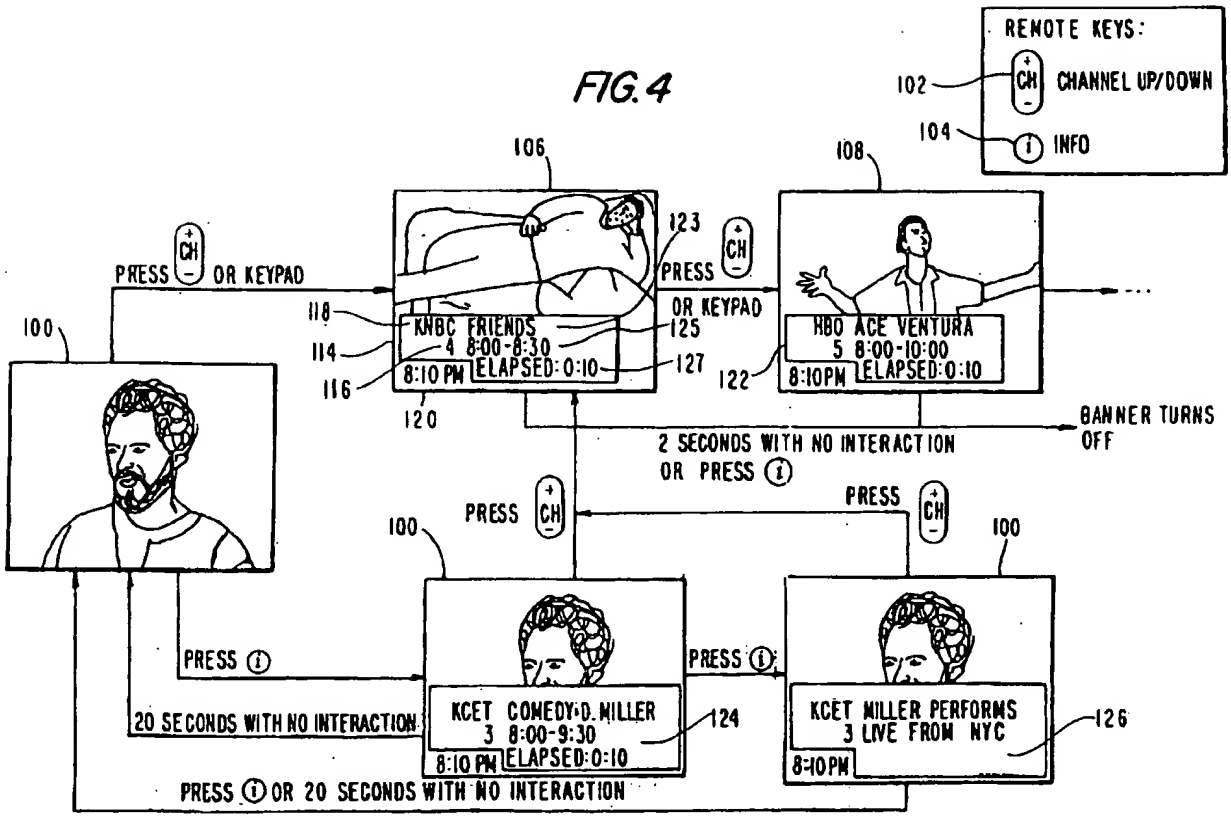

6
30
CPU
31
Memory Monagement Unit
32
NVRAM
DRAM
Flash ROM
ROM
44
NTSC Encoder
RF Modulator
45
RF Output
61
47
S-Video
48
Graphics Subsystem
Baseband Video
50
46
AC-3
51
Audi Subsystem
49
Baseband Audio
52
Keypad
53
54
LED Display
59
Remote
I/O Subsystem
IR Receiver
55
IR Transmitter
VCR
60
56
Accessories Bus
57
10BaseT
58
33
34
35
MPEG-2 Decompress
A/D Converter
IP Router
36
Security
37
QAM 64/256 Demodulate
NTSC Decoder
QPSK Demodulate
QPSK Modulate
40
38
39
43
Tuner
42
Tuner
Transmitter
5
41
Hybrid Fiber Coax Plant

FIG. 3

FIG. 4


REMOTE KEYS:
102
CH
CHANNEL UP/DOWN
104
INFO
106
108
123
PRESS CH OR KEYPAD
PRESS CH
OR KEYPAD
100
118
KNBC FRIENDS
4 8:00-8:30
114
125
116
8:10 PM ELAPSED: 0:10
127
HBO ACE VENTURA
5 8:00-10:00
122
8:10PM ELAPSED: 0:10
120
BANNER TURNS OFF
2 SECONDS WITH NO INTERACTION
OR PRESS i
PRESS CH
PRESS CH
100
100
PRESS i
PRESS i
20 SECONDS WITH NO INTERACTION
KCET COMEDY: D. MILLER
3 8:00-9:30
124
8:10 PM ELAPSED: 0:10
KCET MILLER PERFORMS
3 LIVE FROM NYC
126
8:10PM
PRESS i OR 20 SECONDS WITH NO INTERACTION

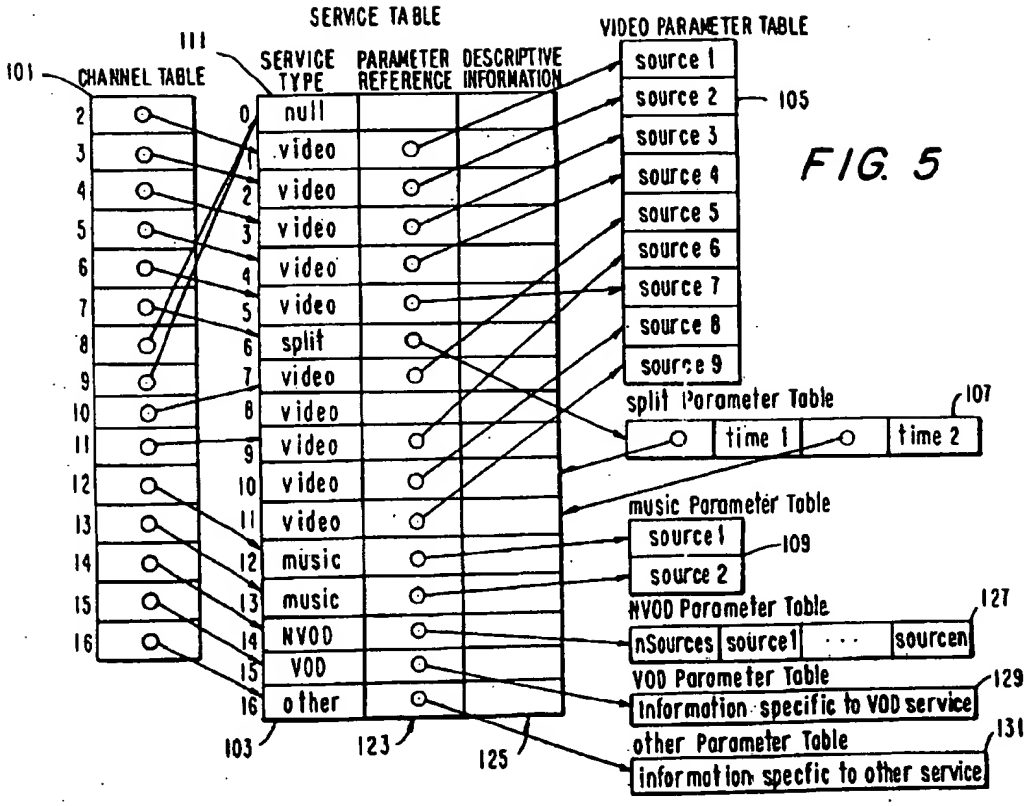

SERVICE TABLE
111
101
CHANNEL TABLE
SERVICE TYPE
PARAMETER REFERENCE
DESCRIPTIVE INFORMATION
VIDEO PARAMETER TABLE
source 1
source 2
source 3
source 4
source 5
source 6
source 7
source 8
source 9
105
null
video
video
video
video
video
split
video
video
video
video
video
music
music
NVOD
VOD
other
split Parameter Table
107
time 1
time 2
music Parameter Table
source 1
source 2
109
NVOD Parameter Table
127
nSources
source1
sourcen
VOD Parameter Table
129
information specific to VOD service
other Parameter Table
131
information specfic to other service
103
123
125

FIG. 5

FIG. 6

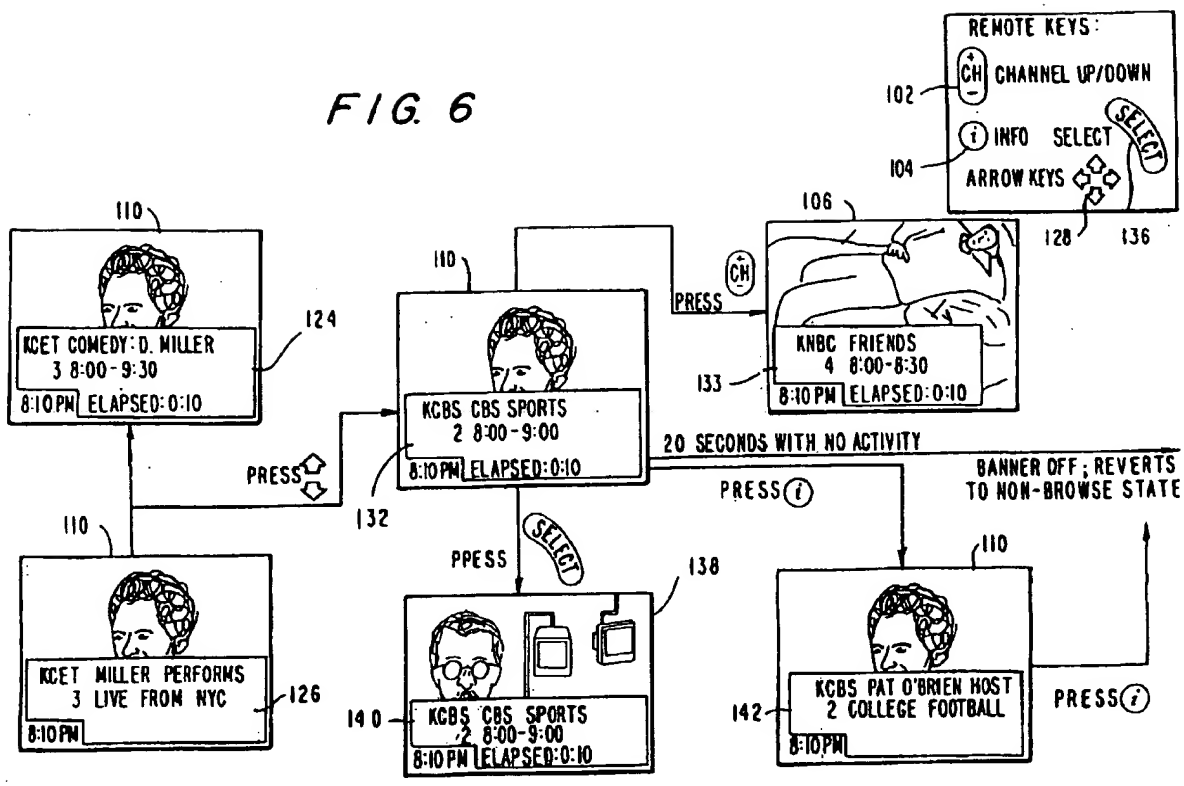

REMOTE KEYS:
CH CHANNEL UP/DOWN
INFO SELECT
ARROW KEYS
SELECT
102
104
128
136
110
KCET COMEDY: D. MILLER
3 8:00-9:30
8:10 PM ELAPSED: 0:10
124
PRESS
106
KNBC FRIENDS
4 8:00-8:30
8:10 PM ELAPSED: 0:10
133
KCBS CBS SPORTS
2 8:00-9:00
8:10 PM ELAPSED: 0:10
132
20 SECONDS WITH NO ACTIVITY
BANNER OFF; REVERTS TO NON-BROWSE STATE
PRESS
PPESS
SELECT
138
KCET MILLER PERFORMS
3 LIVE FROM NYC
8:10 PM
126
KCBS CBS SPORTS
2 8:00-9:00
8:10 PM ELAPSED: 0:10
140
KCBS PAT O'BRIEN HOST
2 COLLEGE FOOTBALL
8:10 PM
142

FIG. 7

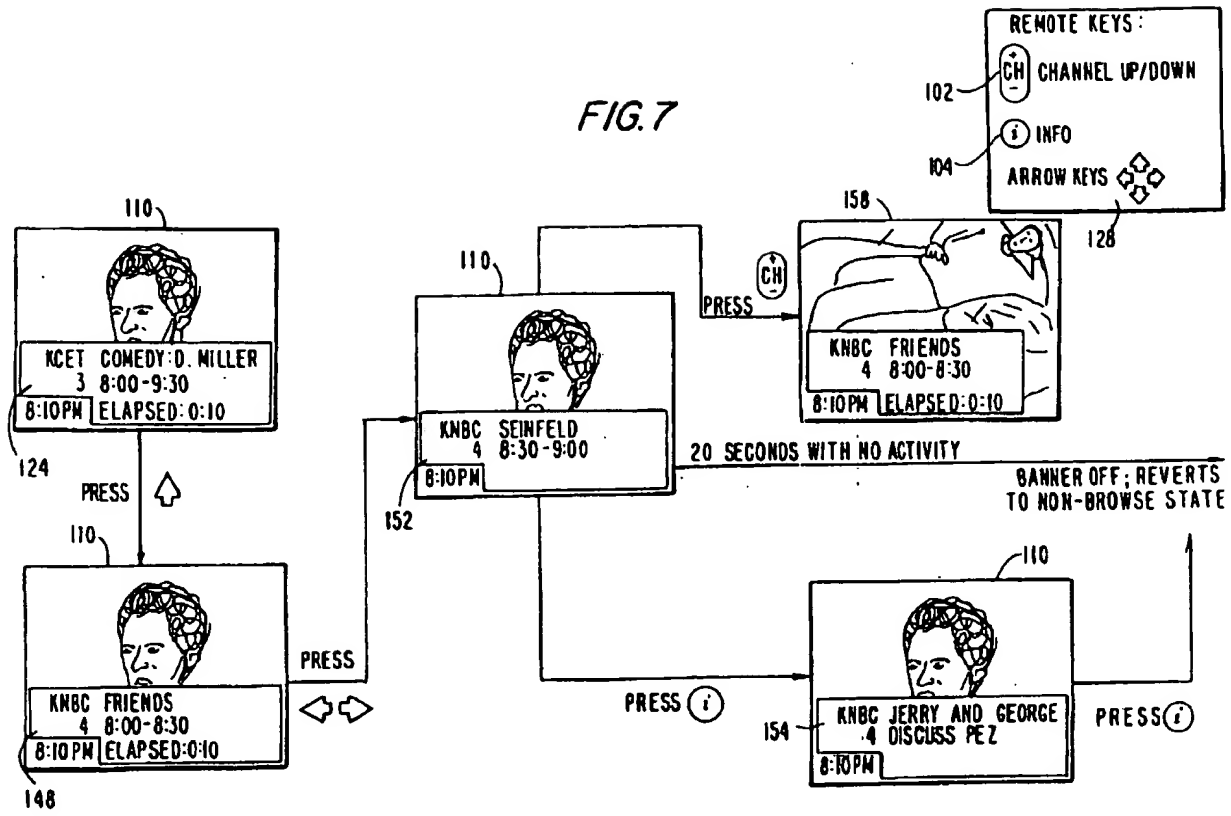
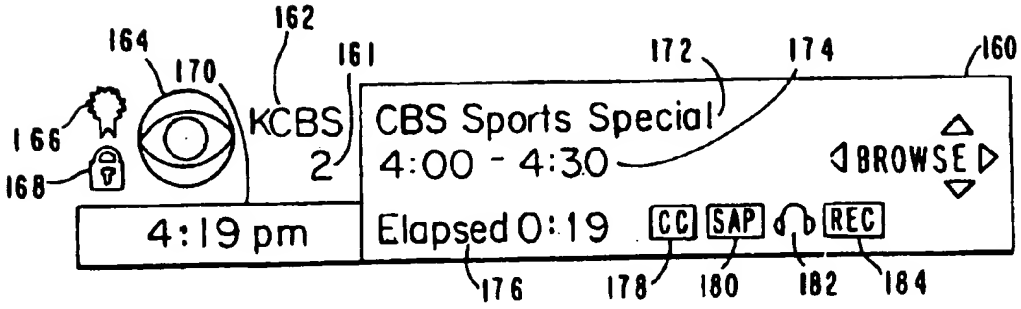

REMOTE KEYS:
CH CHANNEL UP/DOWN
INFO
ARROW KEYS
102
104
128
110
KCET COMEDY:D. MILLER
3 8:00-9:30
8:10PM ELAPSED:0:10
124
PRESS
110
KNBC FRIENDS
4 8:00-8:30
8:10PM ELAPSED:0:10
148
PRESS
110
KNBC SEINFELD
4 8:30-9:00
8:10PM
152
PRESS CH
158
KNBC FRIENDS
4 8:00-8:30
8:10PM ELAPSED:0:10
20 SECONDS WITH NO ACTIVITY
BANNER OFF; REVERTS TO NON-BROWSE STATE
PRESS i
110
KNBC JERRY AND GEORGE
4 DISCUSS PEZ
8:10PM
154
PRESS i

FIG. 8


164
162
161
172
174
160
170
166
KCBS
2
CBS Sports Special
4:00 - 4:30
BROWSE
168
4:19 pm
Elapsed 0:19
CC
SAP
REC
176
178
180
182
184

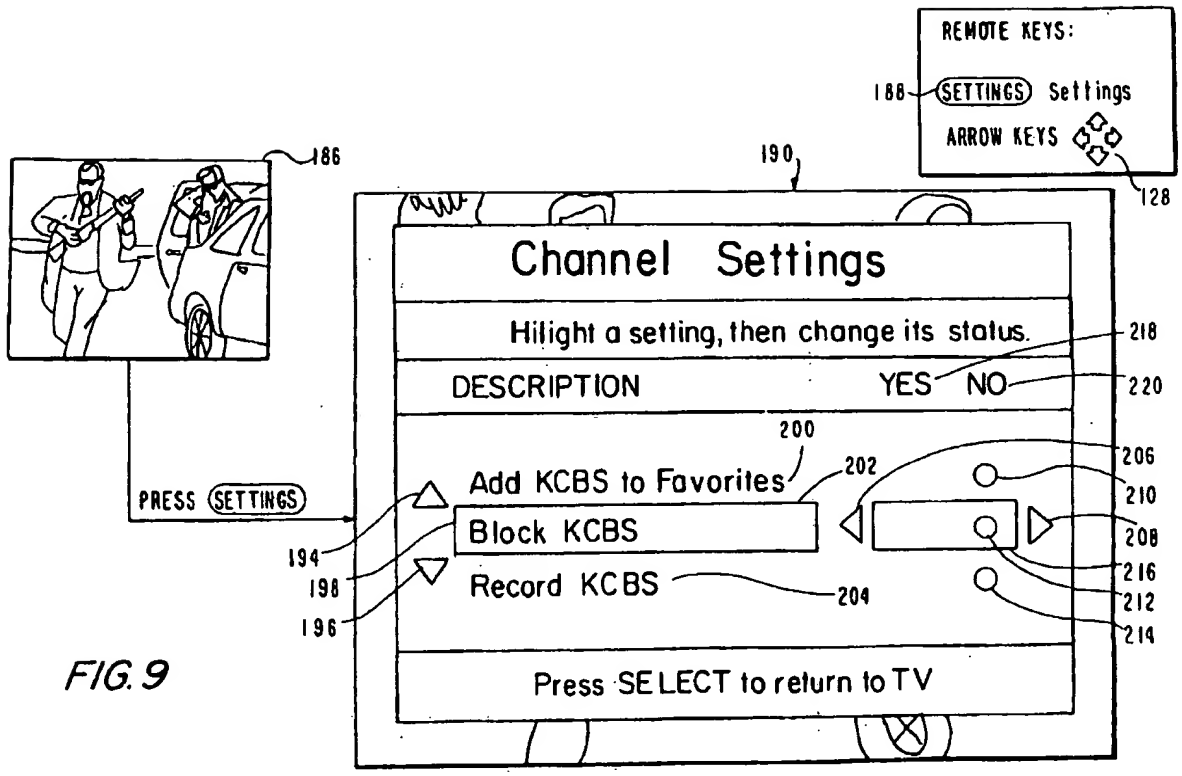

REMOTE KEYS:
188
SETTINGS Settings
ARROW KEYS
128
186
190
Channel Settings
Hilight a setting, then change its status.
218
DESCRIPTION
YES
NO
220
200
206
Add KCBS to Favorites
202
210
PRESS SETTINGS
Block KCBS
208
194
198
Record KCBS
204
216
212
196
214
Press SELECT to return to TV

FIG. 9

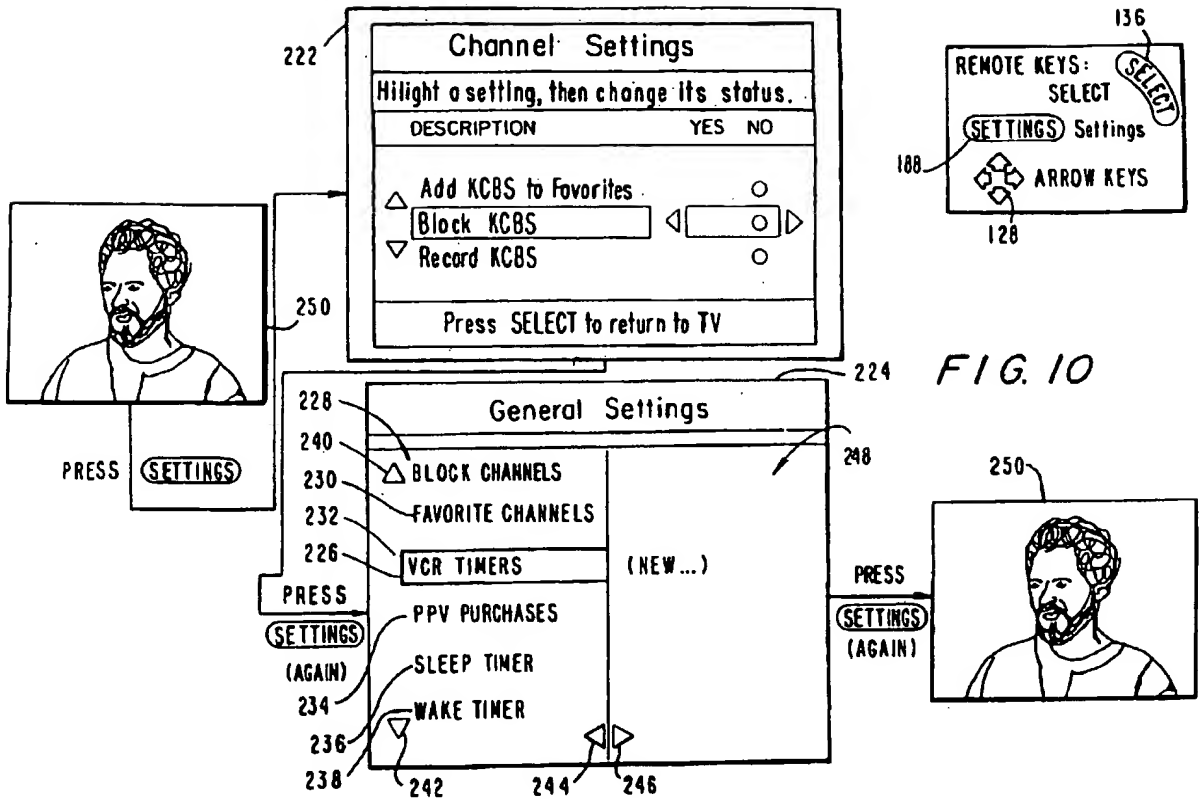

Channel Settings
Hilight a setting, then change its status.
DESCRIPTION YES NO
Add KCBS to Favorites
Block KCBS
Record KCBS
Press SELECT to return to TV
222
250
136
REMOTE KEYS:
SELECT
SELECT
SETTINGS Settings
ARROW KEYS
188
128
PRESS SETTINGS
224
General Settings
228
240
230
232
226
BLOCK CHANNELS
FAVORITE CHANNELS
VCR TIMERS
(NEW...)
PRESS SETTINGS (AGAIN)
PPV PURCHASES
SLEEP TIMER
WAKE TIMER
234
236
238
242
244
246
248
250
PRESS SETTINGS (AGAIN)

FIG. 10

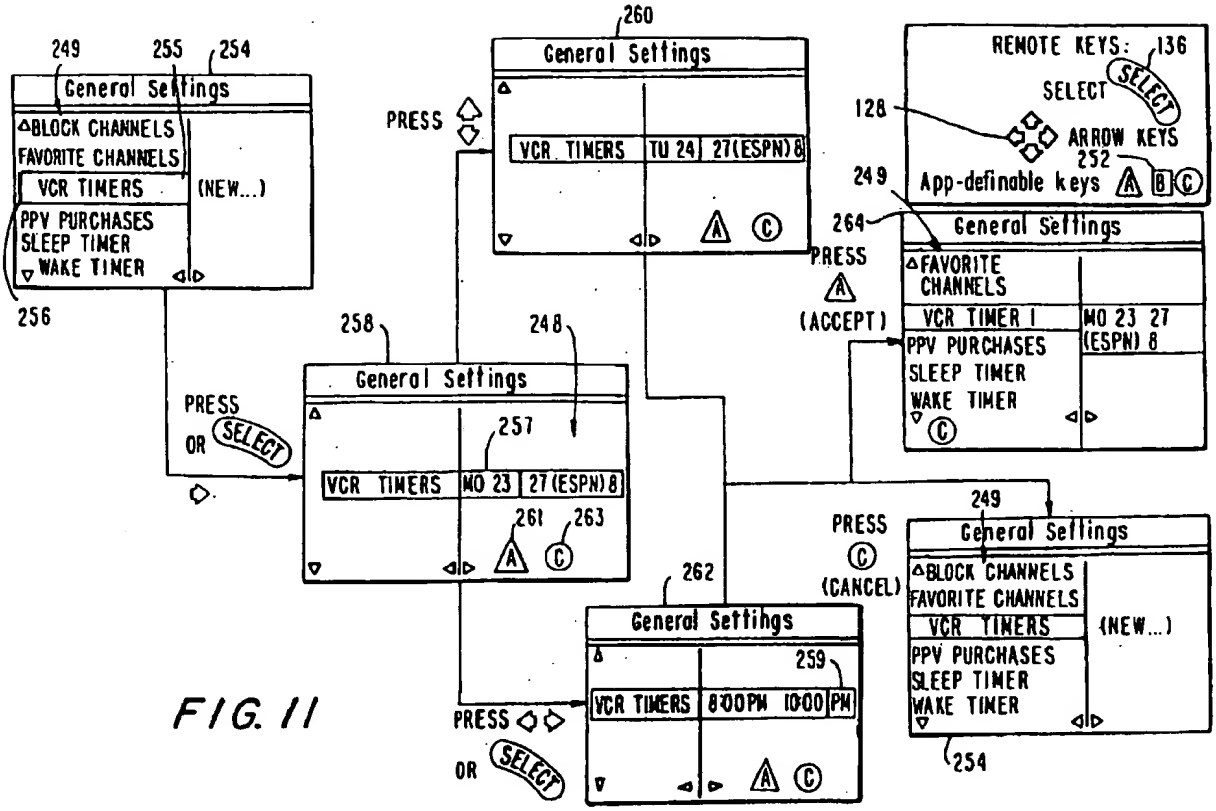

249
255
254
General Settings
BLOCK CHANNELS
FAVORITE CHANNELS
VCR TIMERS
(NEW...)
PPV PURCHASES
SLEEP TIMER
WAKE TIMER
256
260
General Settings
PRESS
VCR TIMERS
TU 24
27(ESPN) 8
REMOTE KEYS:
136
SELECT
SELECT
128
ARROW KEYS
252
App-definable keys
A
B
C
249
264
General Settings
PRESS
A
(ACCEPT)
FAVORITE CHANNELS
VCR TIMER 1
MO 23 27 (ESPN) 8
PPV PURCHASES
SLEEP TIMER
WAKE TIMER
258
248
General Settings
PRESS
OR
SELECT
257
VCR TIMERS
MO 23
27(ESPN) 8
261
263
A
C
249
PRESS
C
(CANCEL)
General Settings
BLOCK CHANNELS
FAVORITE CHANNELS
VCR TIMERS
(NEW...)
PPV PURCHASES
SLEEP TIMER
WAKE TIMER
254
262
General Settings
259
VCR TIMERS
8:00PM
10:00
PM
PRESS
OR
SELECT
A
C

FIG. 11

FIG.12

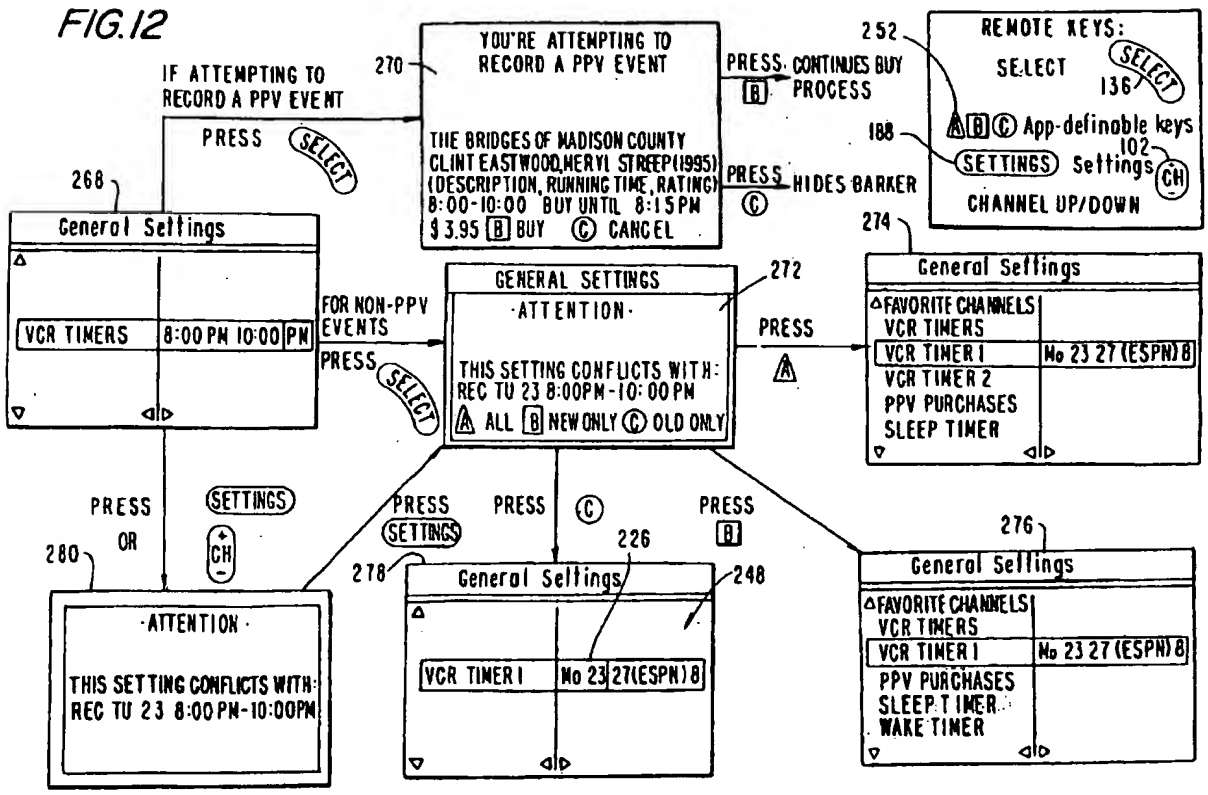

IF ATTEMPTING TO RECORD A PPV EVENT
PRESS
SELECT
268
General Settings
VCR TIMERS
8:00 PM 10:00 PM
FOR NON-PPV EVENTS
PRESS
SELECT
270
YOU'RE ATTEMPTING TO RECORD A PPV EVENT
THE BRIDGES OF MADISON COUNTY
CLINT EASTWOOD, MERYL STREEP (1995)
(DESCRIPTION, RUNNING TIME, RATING)
8:00-10:00 BUY UNTIL 8:15 PM
$3.95 B BUY C CANCEL
PRESS B CONTINUES BUY PROCESS
PRESS C HIDES BARKER
252
REMOTE KEYS:
SELECT
SELECT
136
A B C App-definable keys
188
SETTINGS
Settings
102
CH
CHANNEL UP/DOWN
274
General Settings
FAVORITE CHANNELS
VCR TIMERS
VCR TIMER 1
No 23 27 (ESPN) 8
VCR TIMER 2
PPV PURCHASES
SLEEP TIMER
272
GENERAL SETTINGS
·ATTENTION·
THIS SETTING CONFLICTS WITH:
REC TU 23 8:00PM-10:00PM
A ALL B NEW ONLY C OLD ONLY
PRESS
A
PRESS
OR
SETTINGS
CH
280
·ATTENTION·
THIS SETTING CONFLICTS WITH:
REC TU 23 8:00PM-10:00PM
PRESS
SETTINGS
278
PRESS
C
226
PRESS
B
General Settings
VCR TIMER 1
No 23 27 (ESPN) 8
248
276
General Settings
FAVORITE CHANNELS
VCR TIMERS
VCR TIMER 1
No 23 27 (ESPN) 8
PPV PURCHASES
SLEEP TIMER
WAKE TIMER

FIG. 13

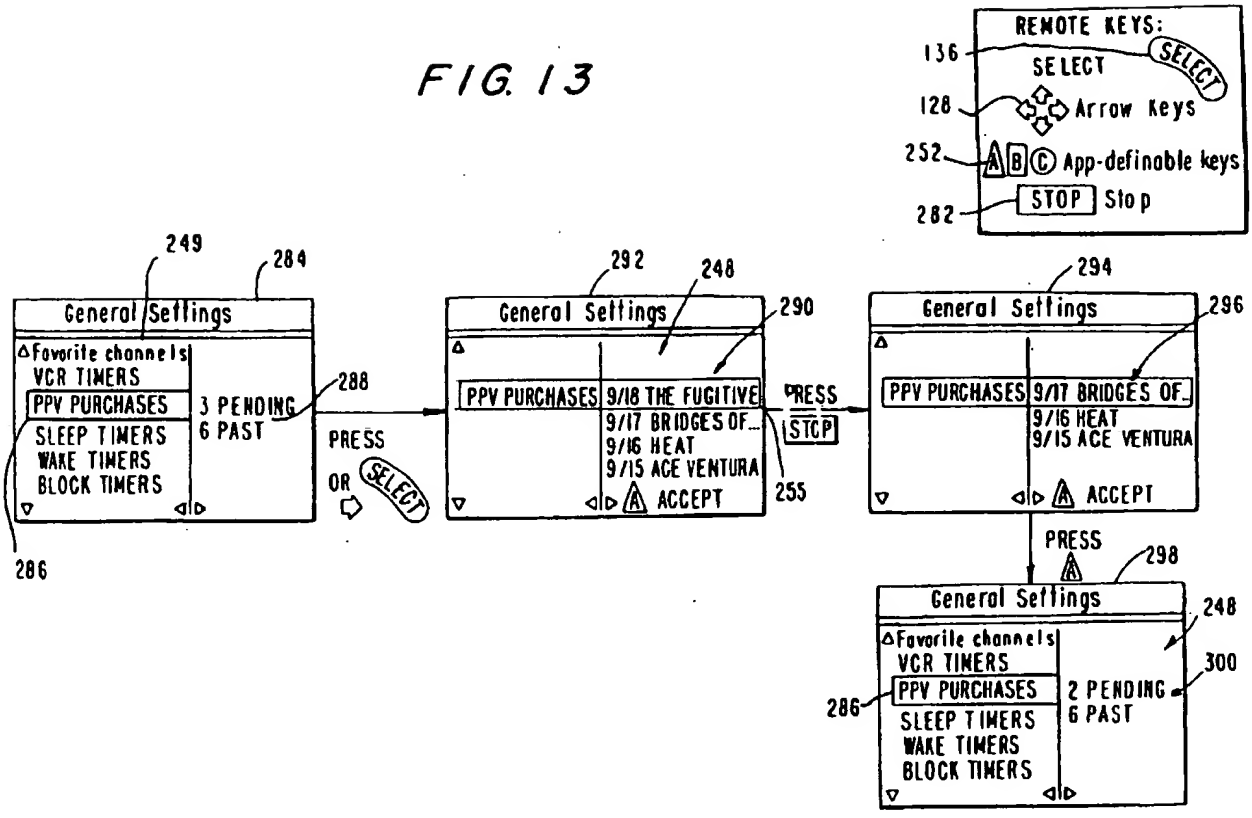
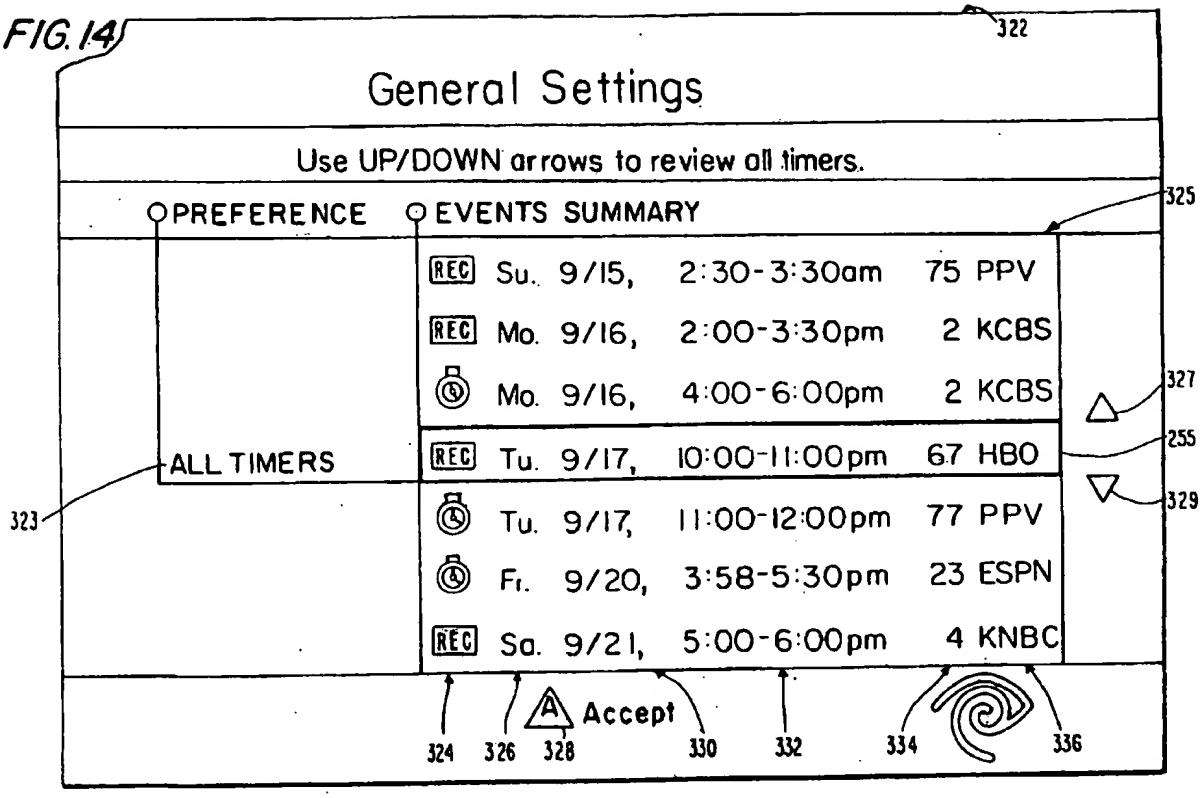

REMOTE KEYS:
136
SELECT
SELECT
128
Arrow Keys
252
A B C App-definable keys
282
STOP
Stop
249
284
General Settings
Favorite channels
VCR TIMERS
PPV PURCHASES
SLEEP TIMERS
WAKE TIMERS
BLOCK TIMERS
3 PENDING
6 PAST
286
288
PRESS
OR
SELECT
292
248
General Settings
290
PPV PURCHASES
9/18 THE FUGITIVE
9/17 BRIDGES OF...
9/16 HEAT
9/15 ACE VENTURA
A ACCEPT
255
PRESS
STOP
294
General Settings
296
PPV PURCHASES
9/17 BRIDGES OF...
9/16 HEAT
9/15 ACE VENTURA
A ACCEPT
PRESS
A
298
General Settings
248
Favorite channels
VCR TIMERS
PPV PURCHASES
SLEEP TIMERS
WAKE TIMERS
BLOCK TIMERS
2 PENDING
6 PAST
300
286

FIG. 14


322
General Settings
Use UP/DOWN arrows to review all timers.
PREFERENCE
EVENTS SUMMARY
325
REC Su. 9/15, 2:30-3:30am 75 PPV
REC Mo. 9/16, 2:00-3:30pm 2 KCBS
Mo. 9/16, 4:00-6:00pm 2 KCBS
327
REC Tu. 9/17, 10:00-11:00pm 67 HBO
255
ALL TIMERS
323
Tu. 9/17, 11:00-12:00pm 77 PPV
329
Fr. 9/20, 3:58-5:30pm 23 ESPN
REC Sa. 9/21, 5:00-6:00pm 4 KNBC
Accept
324
326
328
330
332
334
336

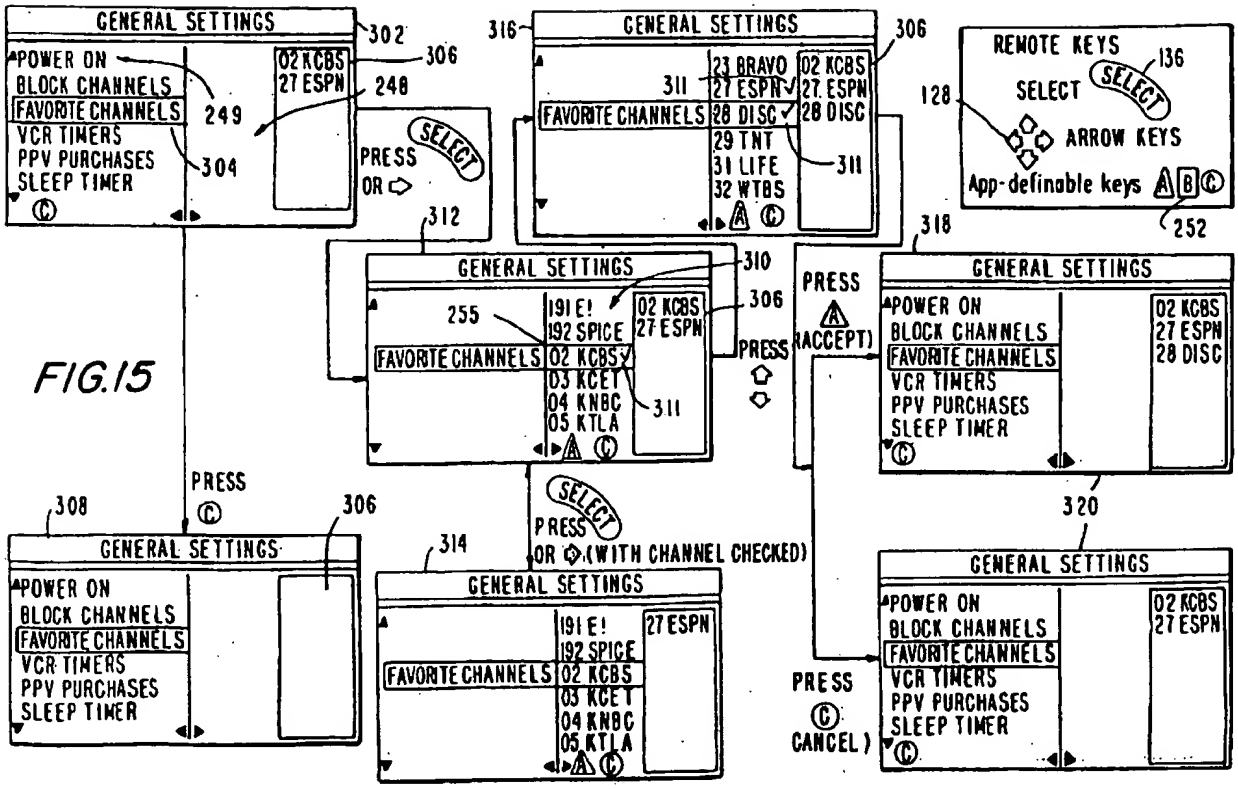

GENERAL SETTINGS
302
POWER ON
BLOCK CHANNELS
FAVORITE CHANNELS
VCR TIMERS
PPV PURCHASES
SLEEP TIMER
249
304
02 KCBS
27 ESPN
306
248
PRESS
OR
SELECT
312
316
GENERAL SETTINGS
23 BRAVO
27 ESPN
28 DISC
29 TNT
31 LIFE
32 WTBS
311
FAVORITE CHANNELS
02 KCBS
27 ESPN
28 DISC
REMOTE KEYS
136
SELECT
128
ARROW KEYS
App-definable keys A B C
252
GENERAL SETTINGS
310
255
191 E!
192 SPICE
FAVORITE CHANNELS
02 KCBS
03 KCET
04 KNBC
05 KTLA
311
318
PRESS
(ACCEPT)
PRESS
GENERAL SETTINGS
POWER ON
BLOCK CHANNELS
FAVORITE CHANNELS
VCR TIMERS
PPV PURCHASES
SLEEP TIMER
28 DISC
320
308
PRESS
GENERAL SETTINGS
POWER ON
BLOCK CHANNELS
FAVORITE CHANNELS
VCR TIMERS
PPV PURCHASES
SLEEP TIMER
314
SELECT
PRESS
OR (WITH CHANNEL CHECKED)
GENERAL SETTINGS
191 E!
192 SPICE
27 ESPN
FAVORITE CHANNELS
02 KCBS
03 KCET
04 KNBC
05 KTLA
PRESS
CANCEL)
GENERAL SETTINGS
POWER ON
BLOCK CHANNELS
FAVORITE CHANNELS
VCR TIMERS
PPV PURCHASES
SLEEP TIMER
02 KCBS
27 ESPN

FIG.15

FIG.16

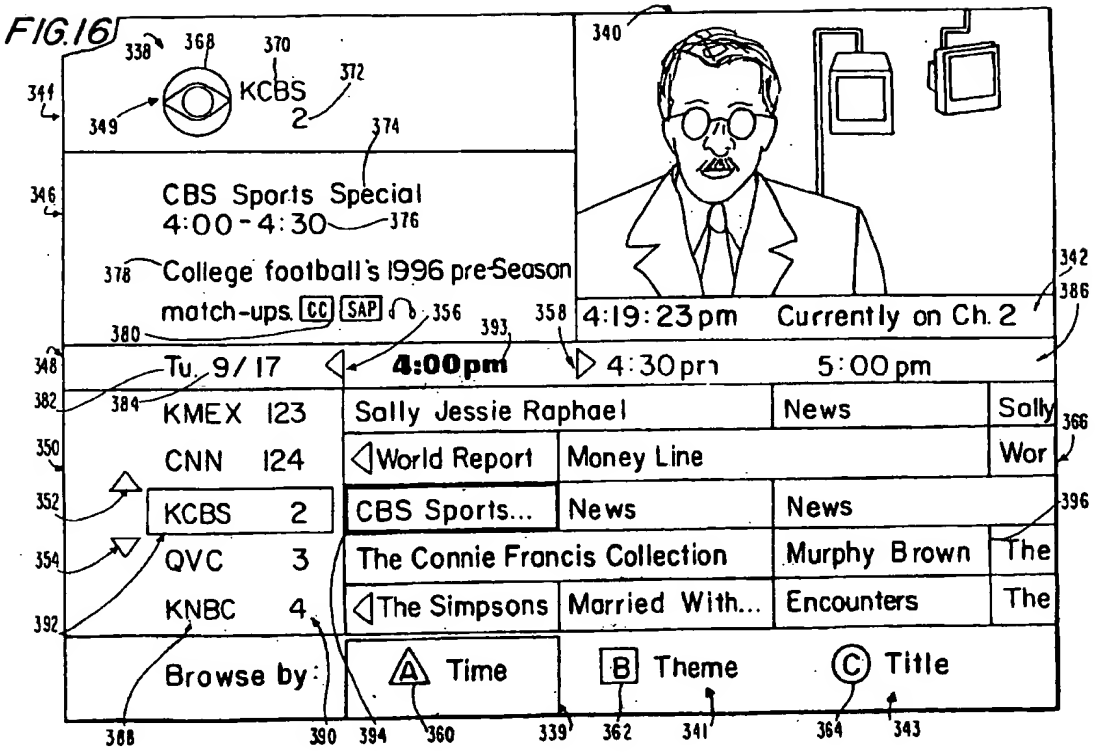

338
368
370
372
341
KCBS
2
349
374
340
CBS Sports Special
346
4:00-4:30
376
College football's 1996 pre-Season
378
match-ups. CC SAP
356
342
386
4:19:23pm Currently on Ch. 2
380
358
393
348
Tu. 9/17
4:00pm
4:30pm
5:00pm
382
384
KMEX 123
Sally Jessie Raphael
News
Sally
366
350
CNN 124
World Report
Money Line
Wor
352
KCBS 2
CBS Sports...
News
News
396
354
QVC 3
The Connie Francis Collection
Murphy Brown
The
392
KNBC 4
The Simpsons
Married With...
Encounters
The
Browse by:
A Time
B Theme
C Title
388
390
394
360
339
362
341
364
343

FIG. 17

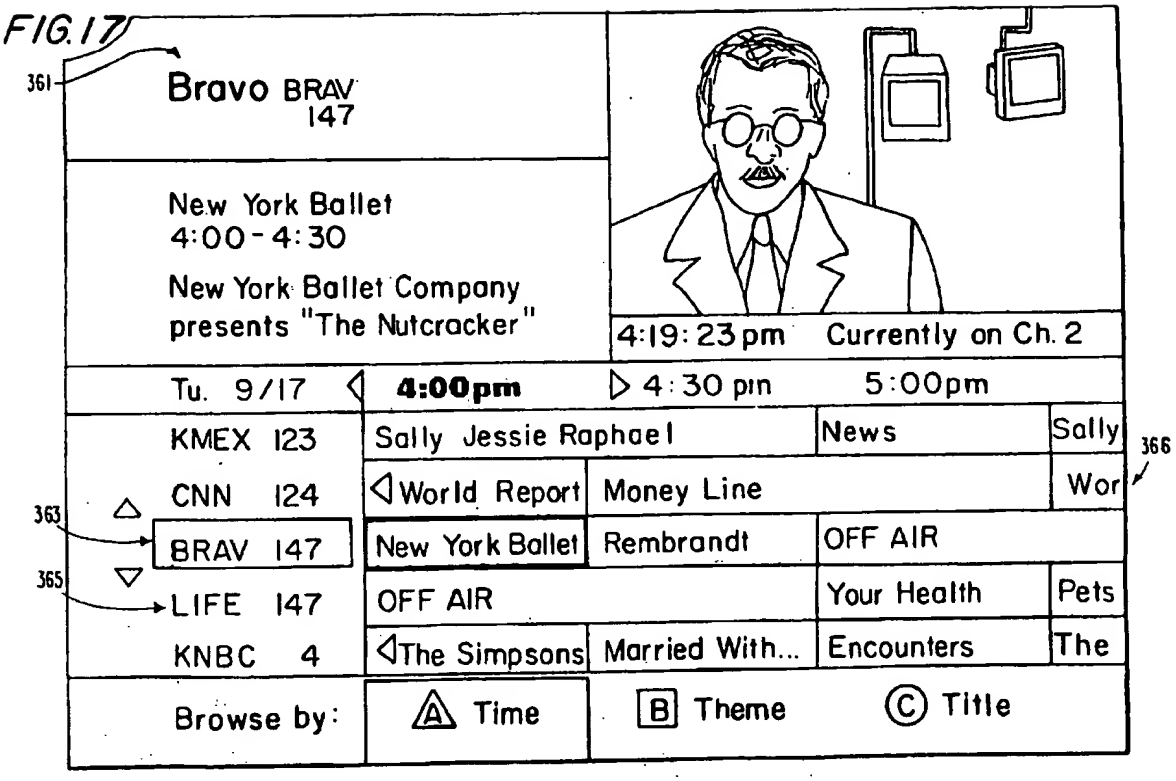
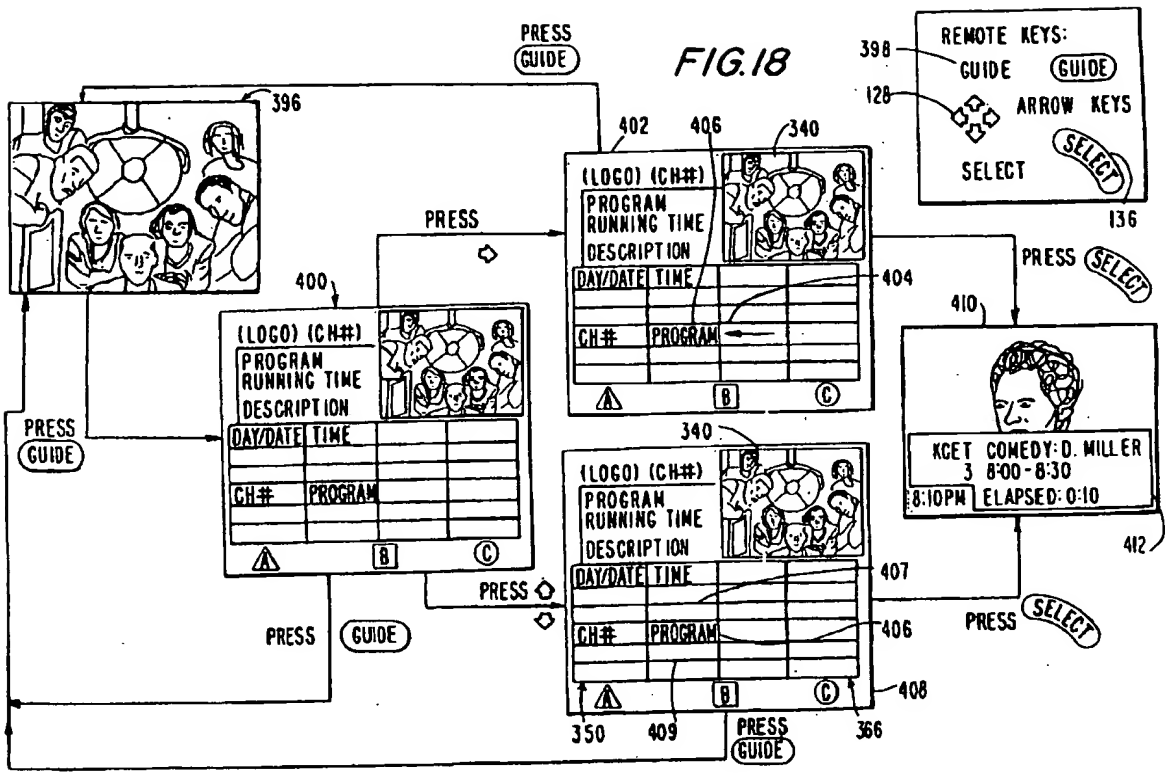

361
Bravo BRAV 147
New York Ballet
4:00 - 4:30
New York Ballet Company presents "The Nutcracker"
4:19:23 pm Currently on Ch. 2
Tu. 9/17
4:00pm
4:30 pm
5:00pm
KMEX 123
Sally Jessie Raphael
News
Sally
366
CNN 124
World Report
Money Line
Wor
363
BRAV 147
New York Ballet
Rembrandt
OFF AIR
365
LIFE 147
OFF AIR
Your Health
Pets
KNBC 4
The Simpsons
Married With...
Encounters
The
Browse by:
A Time
B Theme
C Title

FIG.18


PRESS
GUIDE
396
PRESS
400
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
A
B
C
PRESS
GUIDE
PRESS
GUIDE
402
406
340
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
404
PRESS
340
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
407
406
408
350
409
366
PRESS
GUIDE
398
REMOTE KEYS:
GUIDE
GUIDE
128
ARROW KEYS
SELECT
SELECT
136
PRESS
SELECT
410
KCET COMEDY: D. MILLER
3 8:00-8:30
8:10PM ELAPSED: 0:10
412
PRESS
SELECT

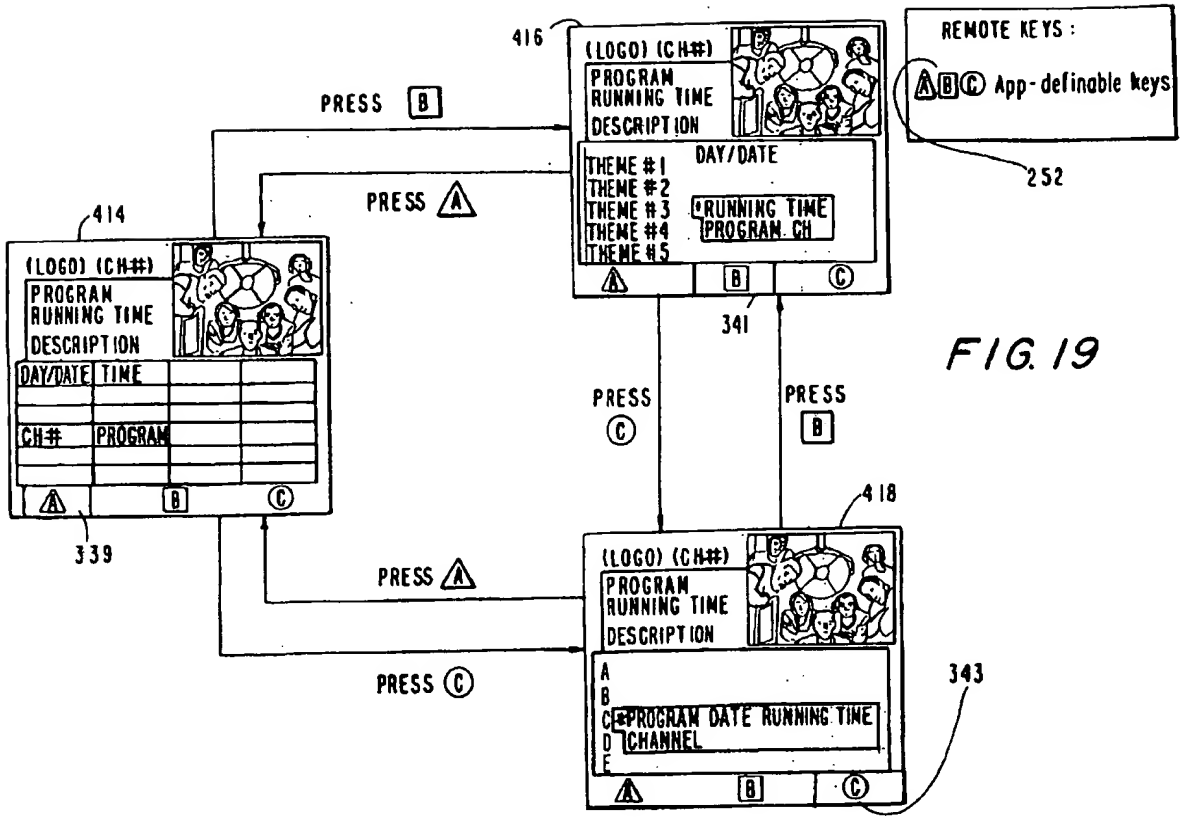

416
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE
THEME #1
THEME #2
THEME #3
THEME #4
THEME #5
*RUNNING TIME
*PROGRAM CH
A B C
341
REMOTE KEYS :
A B C App-definable keys
252
PRESS B
PRESS A
414
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE
TIME
CH#
PROGRAM
A B C
339
PRESS C
PRESS B
418
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
A
B
C *PROGRAM DATE RUNNING TIME
D CHANNEL
E
A B C
343
PRESS A
PRESS C

FIG. 19

FIG. 20

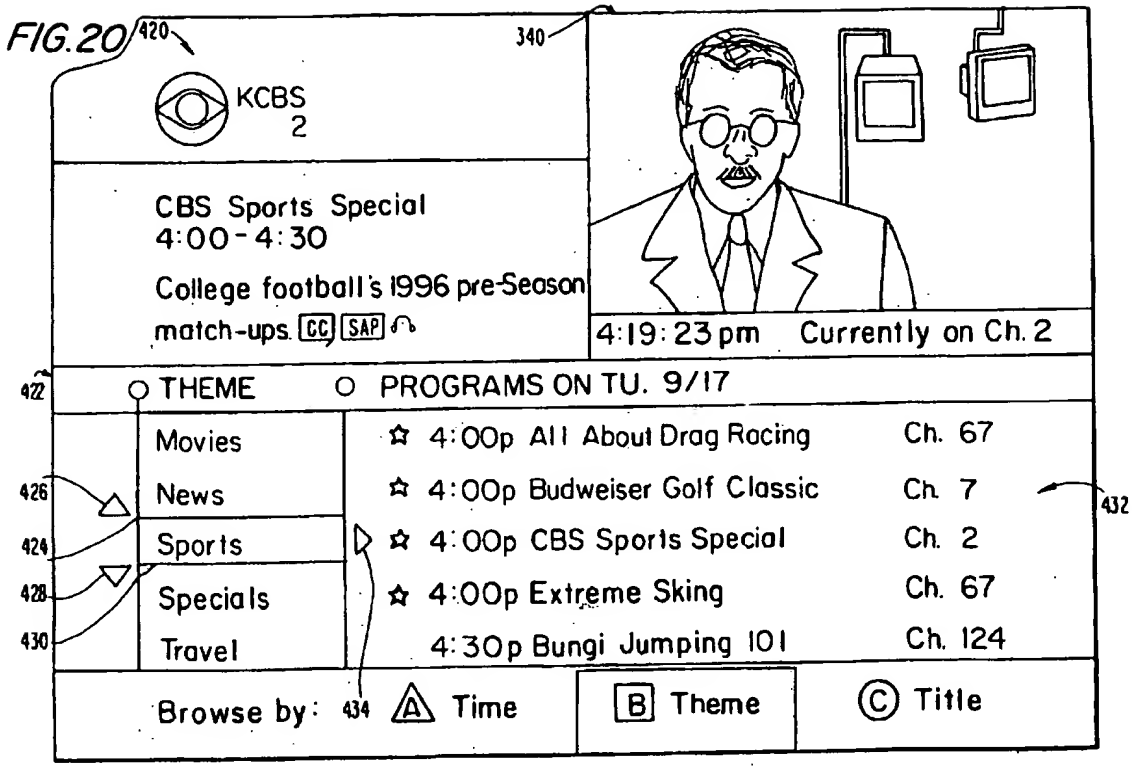

420
340
KCBS
2
CBS Sports Special
4:00 - 4:30
College football's 1996 pre-Season
match-ups. CC SAP
4:19:23 pm Currently on Ch. 2
422
THEME
PROGRAMS ON TU. 9/17
Movies
News
Sports
Specials
Travel
426
424
428
430
☆ 4:00p All About Drag Racing Ch. 67
☆ 4:00p Budweiser Golf Classic Ch. 7
☆ 4:00p CBS Sports Special Ch. 2
☆ 4:00p Extreme Sking Ch. 67
4:30p Bungi Jumping 101 Ch. 124
432
Browse by:
434
A Time
B Theme
C Title

FIG. 21

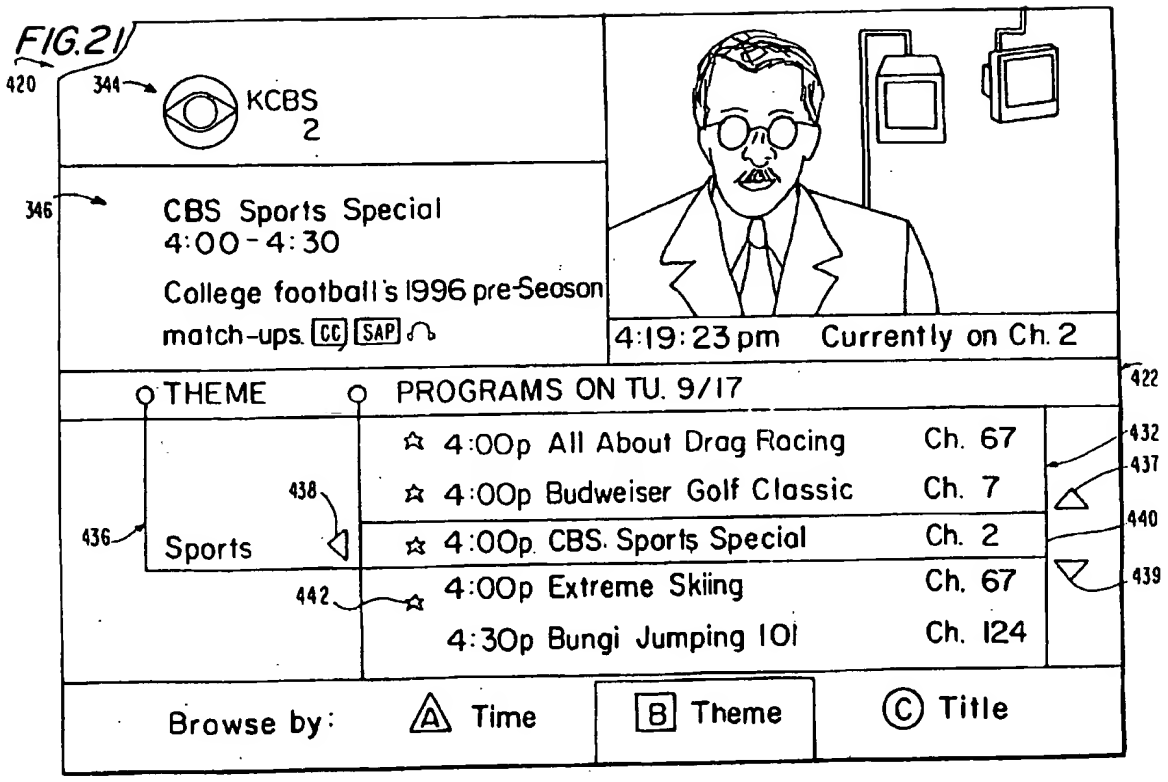

420
344
KCBS
2
346
CBS Sports Special
4:00 - 4:30
College football's 1996 pre-Seoson
match-ups. CC SAP
4:19:23 pm Currently on Ch. 2
422
THEME
PROGRAMS ON TU. 9/17
☆ 4:00p All About Drag Racing Ch. 67
☆ 4:00p Budweiser Golf Classic Ch. 7
☆ 4:00p CBS. Sports Special Ch. 2
☆ 4:00p Extreme Skiing Ch. 67
4:30p Bungi Jumping 101 Ch. 124
438
436
Sports
442
432
437
440
439
Browse by: A Time B Theme C Title

FIG.22

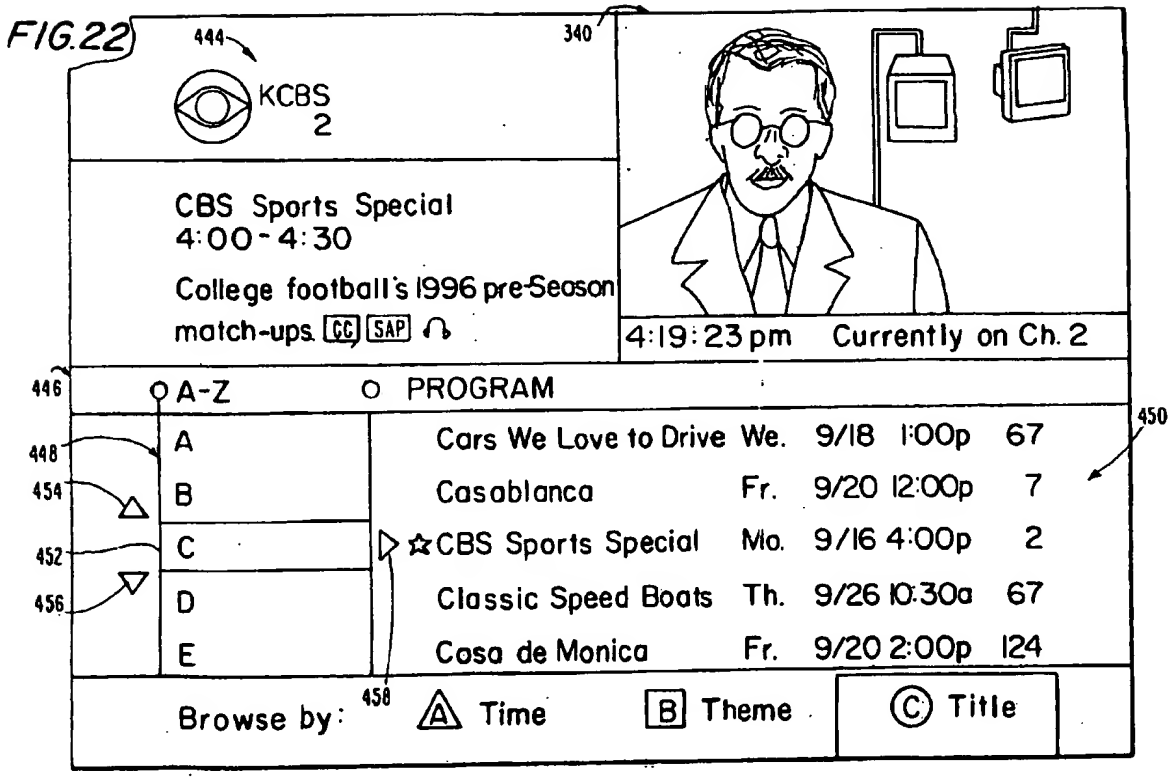
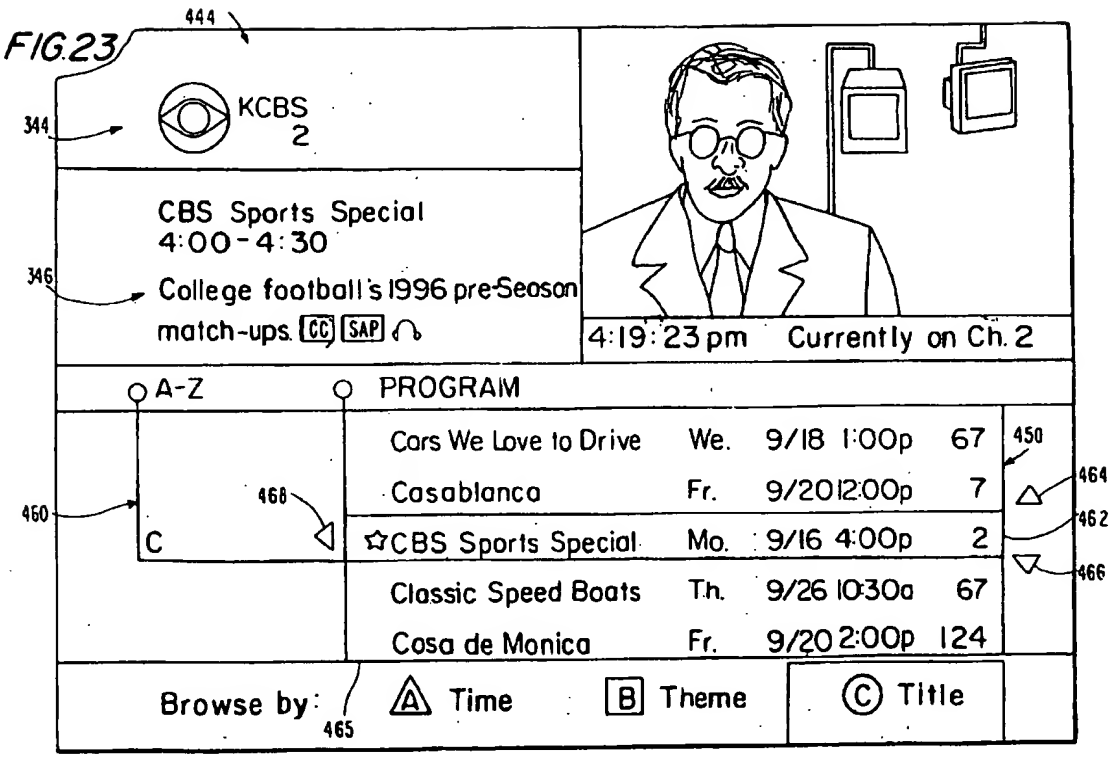

444
KCBS
2
340
CBS Sports Special
4:00-4:30
College football's 1996 pre-Season
match-ups. CC SAP
4:19:23 pm Currently on Ch. 2
446
A-Z
PROGRAM
448
454
452
456
A
B
C
D
E
Cars We Love to Drive We. 9/18 1:00p 67
Casablanca Fr. 9/20 12:00p 7
☆CBS Sports Special Mo. 9/16 4:00p 2
Classic Speed Boats Th. 9/26 10:30a 67
Casa de Monica Fr. 9/20 2:00p 124
450
458
Browse by:
A Time
B Theme
C Title

FIG.23


444
344
KCBS
2
CBS Sports Special
4:00-4:30
346
College football's 1996 pre-Season
match-ups. CC SAP
4:19:23 pm Currently on Ch. 2
A-Z
PROGRAM
460
C
468
Cars We Love to Drive We. 9/18 1:00p 67
Casablanca Fr. 9/20 12:00p 7
☆CBS Sports Special Mo. 9/16 4:00p 2
Classic Speed Boats Th. 9/26 10:30a 67
Cosa de Monica Fr. 9/20 2:00p 124
450
464
462
466
Browse by:
A Time
B Theme
C Title
465

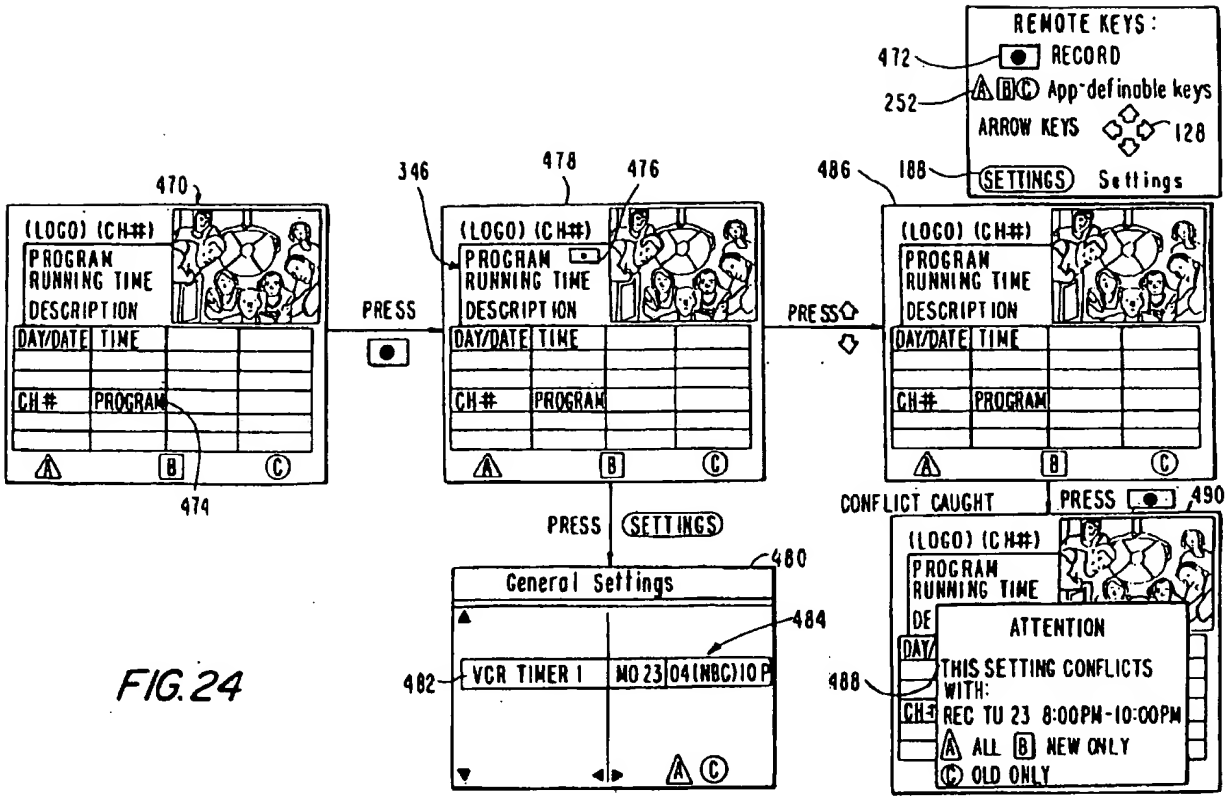

REMOTE KEYS:
472
RECORD
252
A B C App-definable keys
ARROW KEYS
128
188
SETTINGS
Settings
470
346
478
476
486
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE
TIME
CH #
PROGRAM
A
B
C
474
PRESS
PRESS
PRESS
SETTINGS
CONFLICT CAUGHT
PRESS
490
480
General Settings
484
482
VCR TIMER 1
MO 23
04(NBC)10P
488
ATTENTION
THIS SETTING CONFLICTS
WITH:
REC TU 23 8:00PM-10:00PM
A ALL B NEW ONLY
C OLD ONLY

FIG. 24

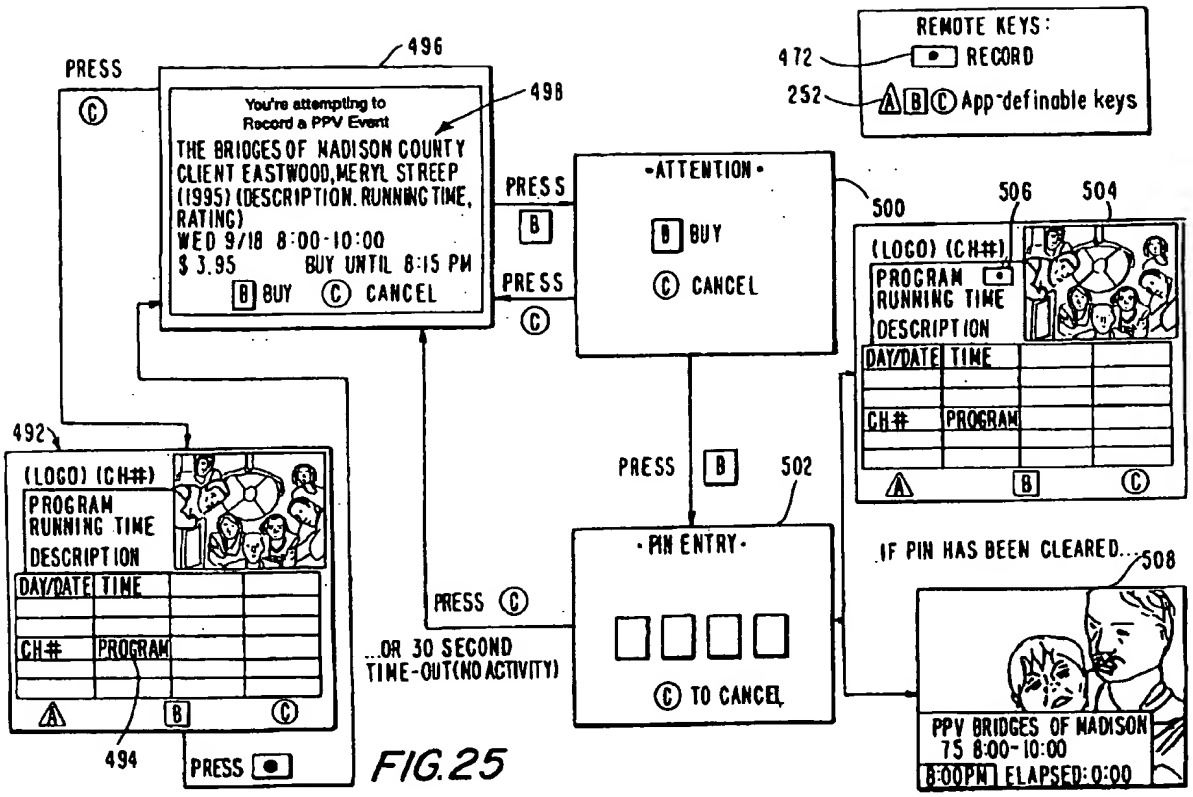

REMOTE KEYS:
472
RECORD
252
A B C App-definable keys
496
PRESS
C
You're attempting to Record a PPV Event
498
THE BRIDGES OF MADISON COUNTY
CLIENT EASTWOOD, MERYL STREEP
(1995) (DESCRIPTION. RUNNING TIME, RATING)
WED 9/18 8:00-10:00
$ 3.95 BUY UNTIL 8:15 PM
B BUY C CANCEL
PRESS
B
PRESS
C
-ATTENTION-
B BUY
C CANCEL
500
506
504
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
A B C
492
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
A B C
494
PRESS
PRESS B
502
-PIN ENTRY-
C TO CANCEL
PRESS C
...OR 30 SECOND TIME-OUT(NO ACTIVITY)
IF PIN HAS BEEN CLEARED...
508
PPV BRIDGES OF MADISON
7S 8:00-10:00
8:00PM ELAPSED: 0:00

FIG. 25

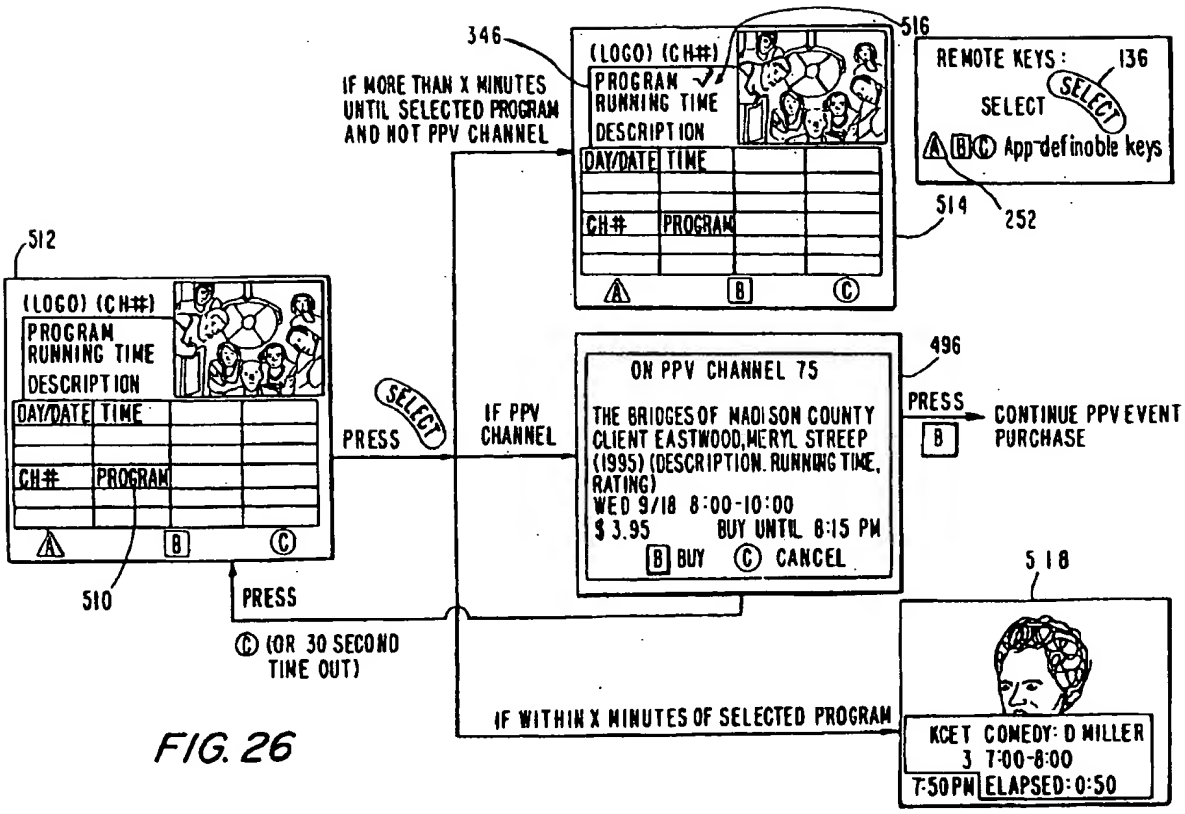

346
516
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
A B C
IF MORE THAN X MINUTES UNTIL SELECTED PROGRAM AND NOT PPV CHANNEL
REMOTE KEYS: 136
SELECT
A B C App-definable keys
252
514
512
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
A B C
510
PRESS
SELECT
IF PPV CHANNEL
ON PPV CHANNEL 75
THE BRIDGES OF MADISON COUNTY
CLIENT EASTWOOD, MERYL STREEP
(1995) (DESCRIPTION. RUNNING TIME, RATING)
WED 9/18 8:00-10:00
$ 3.95 BUY UNTIL 8:15 PM
B BUY C CANCEL
496
PRESS
B
CONTINUE PPV EVENT PURCHASE
C (OR 30 SECOND TIME OUT)
518
IF WITHIN X MINUTES OF SELECTED PROGRAM
KCET COMEDY: D MILLER
3 7:00-8:00
7:50PM ELAPSED: 0:50

FIG. 26

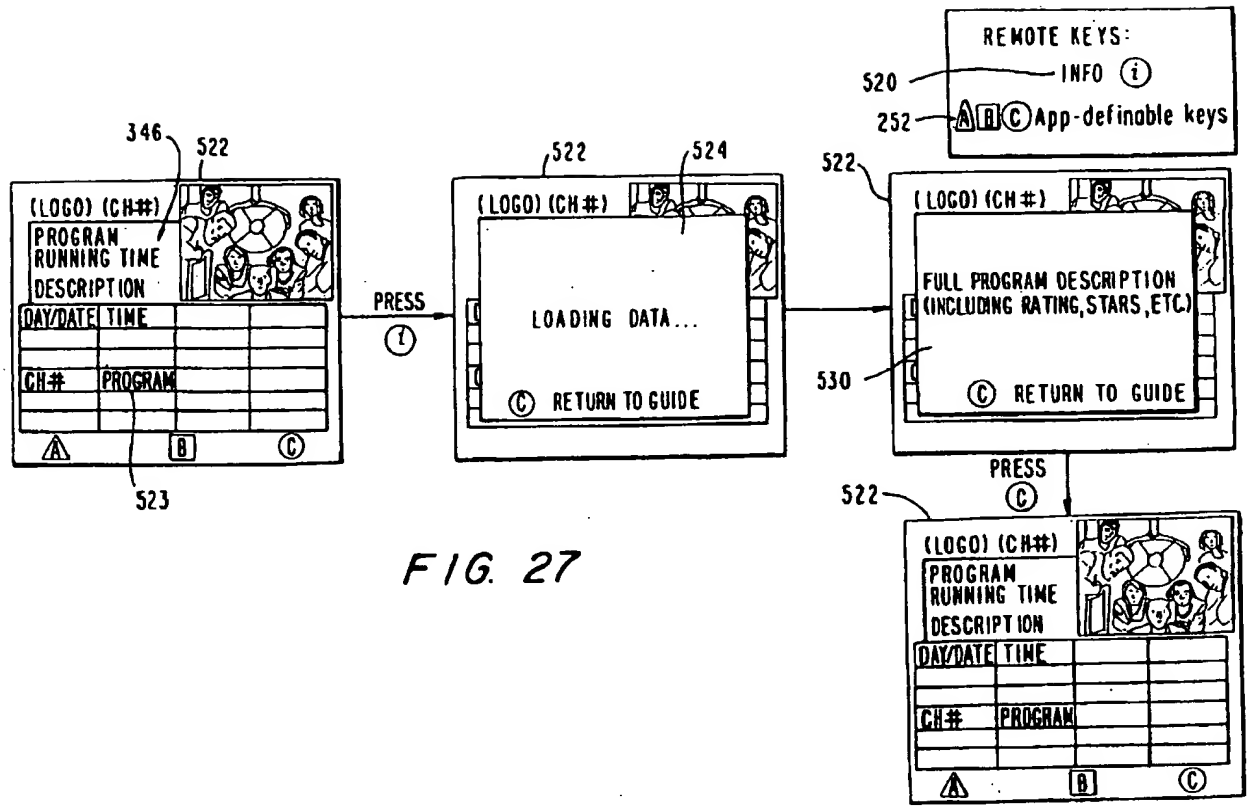

REMOTE KEYS:
INFO (i)
A B C App-definable keys
520
252
346
522
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
A
B
C
523
PRESS
(i)
522
524
(LOGO) (CH#)
LOADING DATA...
C RETURN TO GUIDE
522
(LOGO) (CH#)
FULL PROGRAM DESCRIPTION
(INCLUDING RATING, STARS, ETC.)
530
C RETURN TO GUIDE
PRESS
C
522
(LOGO) (CH#)
PROGRAM
RUNNING TIME
DESCRIPTION
DAY/DATE TIME
CH# PROGRAM
A
B
C

FIG. 27

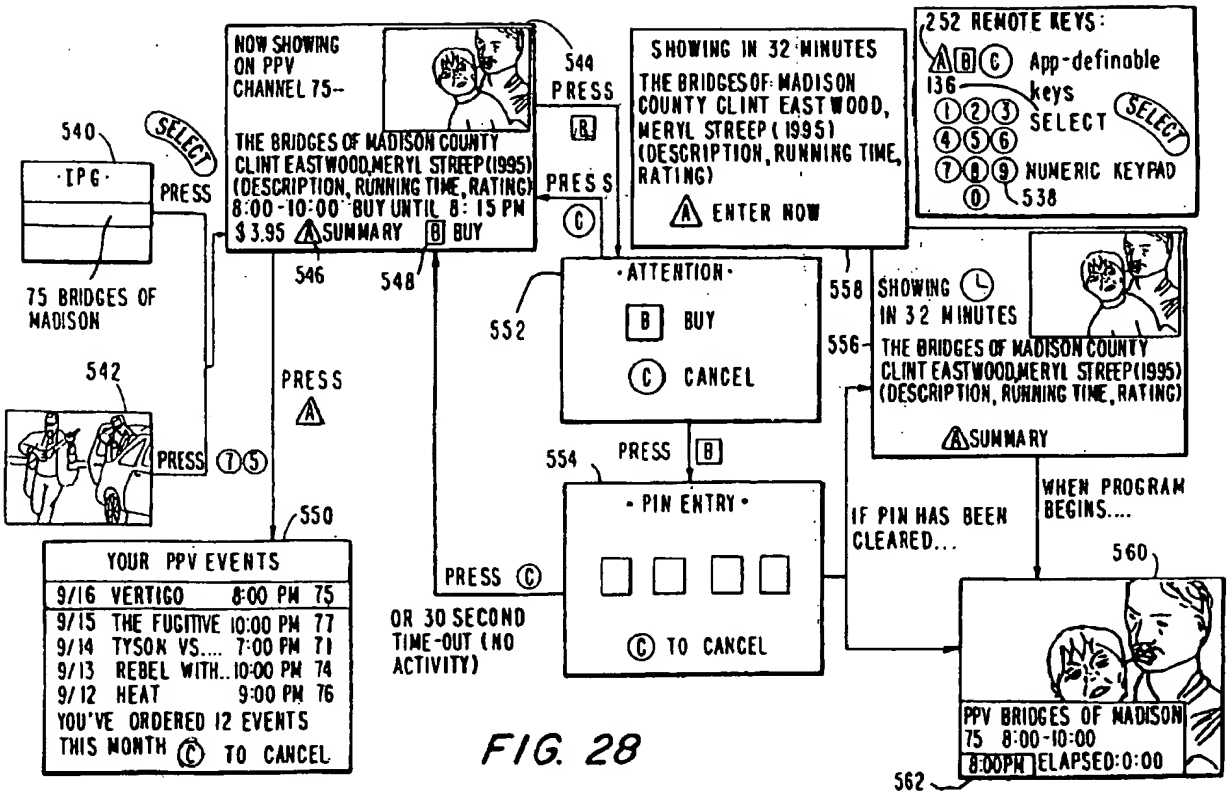

540
SELECT
·IPG·
PRESS
75 BRIDGES OF MADISON
542
PRESS 7 5
NOW SHOWING ON PPV CHANNEL 75--
THE BRIDGES OF MADISON COUNTY CLINT EASTWOOD, MERYL STREEP (1995) (DESCRIPTION, RUNNING TIME, RATING)
8:00-10:00 BUY UNTIL 8:15 PM
$3.95 A SUMMARY B BUY
544
PRESS B
PRESS C
546
548
PRESS A
550
YOUR PPV EVENTS
9/16 VERTIGO 8:00 PM 75
9/15 THE FUGITIVE 10:00 PM 77
9/14 TYSON VS.... 7:00 PM 71
9/13 REBEL WITH.. 10:00 PM 74
9/12 HEAT 9:00 PM 76
YOU'VE ORDERED 12 EVENTS THIS MONTH C TO CANCEL
SHOWING IN 32 MINUTES
THE BRIDGES OF MADISON COUNTY CLINT EASTWOOD, MERYL STREEP (1995) (DESCRIPTION, RUNNING TIME, RATING)
A ENTER NOW
252 REMOTE KEYS:
A B C App-definable keys
136
1 2 3 4 5 6 7 8 9 SELECT
0 NUMERIC KEYPAD
538
SELECT
·ATTENTION·
B BUY
C CANCEL
552
558
556
SHOWING IN 32 MINUTES
THE BRIDGES OF MADISON COUNTY CLINT EASTWOOD, MERYL STREEP (1995) (DESCRIPTION, RUNNING TIME, RATING)
A SUMMARY
554
PRESS B
· PIN ENTRY ·
C TO CANCEL
PRESS C
OR 30 SECOND TIME-OUT (NO ACTIVITY)
IF PIN HAS BEEN CLEARED...
WHEN PROGRAM BEGINS....
560
PPV BRIDGES OF MADISON
75 8:00-10:00
8:00PM ELAPSED:0:00
562

FIG. 28

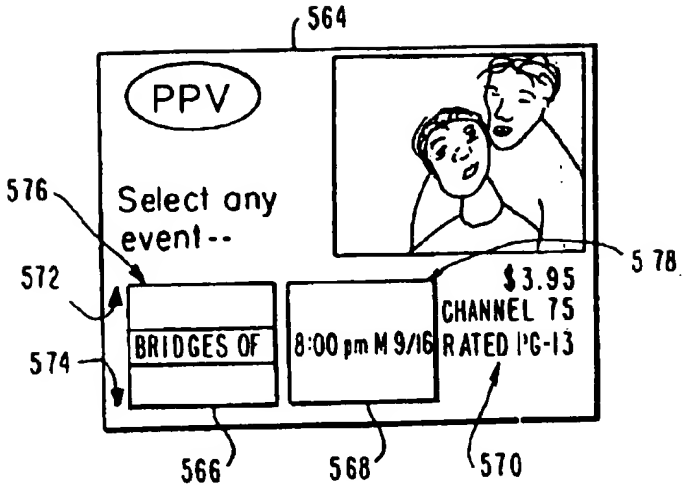

564
PPV
Select any event--
576
572
574
BRIDGES OF
8:00 pm M 9/16
$3.95
CHANNEL 75
RATED PG-13
578
566
568
570

FIG. 29

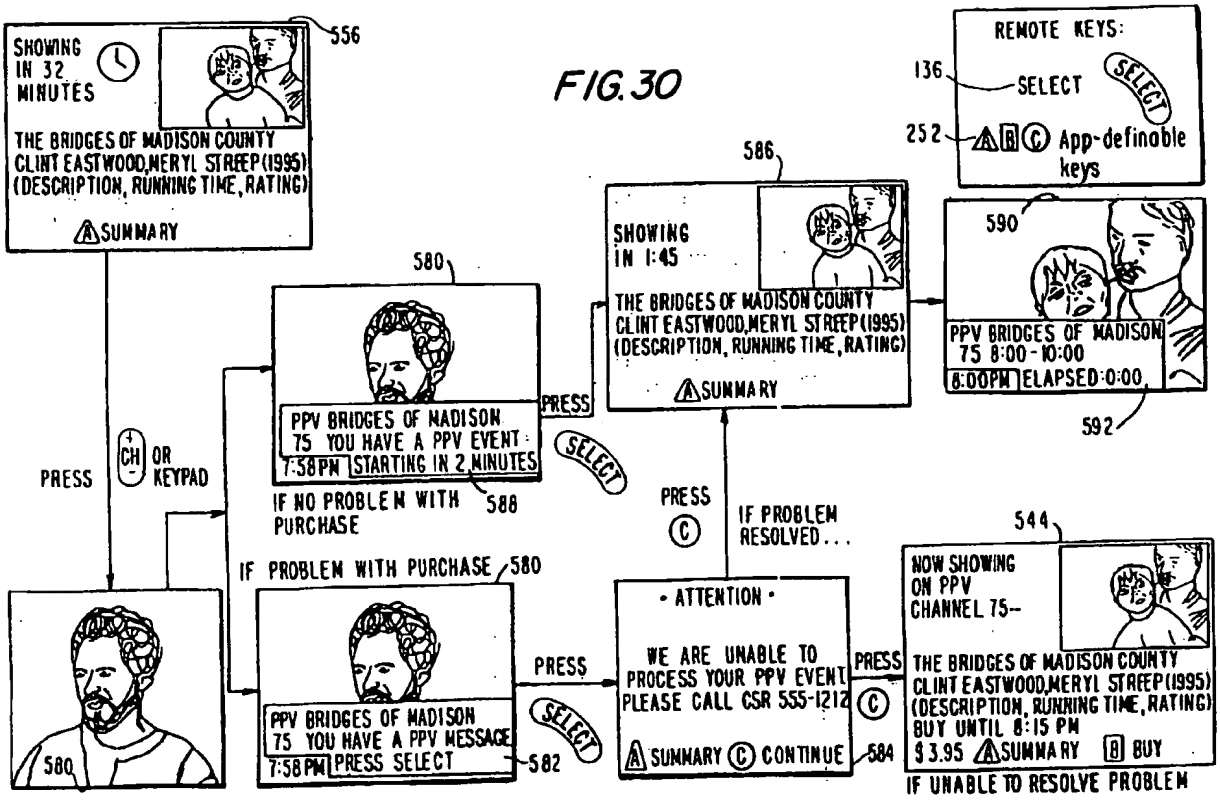

SHOWING IN 32 MINUTES
THE BRIDGES OF MADISON COUNTY
CLINT EASTWOOD, MERYL STREEP (1995)
(DESCRIPTION, RUNNING TIME, RATING)
A SUMMARY
556
PRESS
+ CH -
OR KEYPAD
580
PPV BRIDGES OF MADISON
75 YOU HAVE A PPV EVENT
7:58PM STARTING IN 2 MINUTES
IF NO PROBLEM WITH PURCHASE
588
PRESS
SELECT
SHOWING IN 1:45
THE BRIDGES OF MADISON COUNTY
CLINT EASTWOOD, MERYL STREEP (1995)
(DESCRIPTION, RUNNING TIME, RATING)
A SUMMARY
586
REMOTE KEYS:
136
SELECT
252
A B C App-definable keys
590
PPV BRIDGES OF MADISON
75 8:00 - 10:00
8:00PM ELAPSED 0:00
592
IF PROBLEM WITH PURCHASE
580
PPV BRIDGES OF MADISON
75 YOU HAVE A PPV MESSAGE
7:58PM PRESS SELECT
582
PRESS
SELECT
• ATTENTION •
WE ARE UNABLE TO PROCESS YOUR PPV EVENT
PLEASE CALL CSR 555-1212
A SUMMARY C CONTINUE
584
PRESS C
IF PROBLEM RESOLVED...
544
NOW SHOWING ON PPV CHANNEL 75--
THE BRIDGES OF MADISON COUNTY
CLINT EASTWOOD, MERYL STREEP (1995)
(DESCRIPTION, RUNNING TIME, RATING)
BUY UNTIL 8:15 PM
$3.95 A SUMMARY B BUY
IF UNABLE TO RESOLVE PROBLEM

FIG. 30

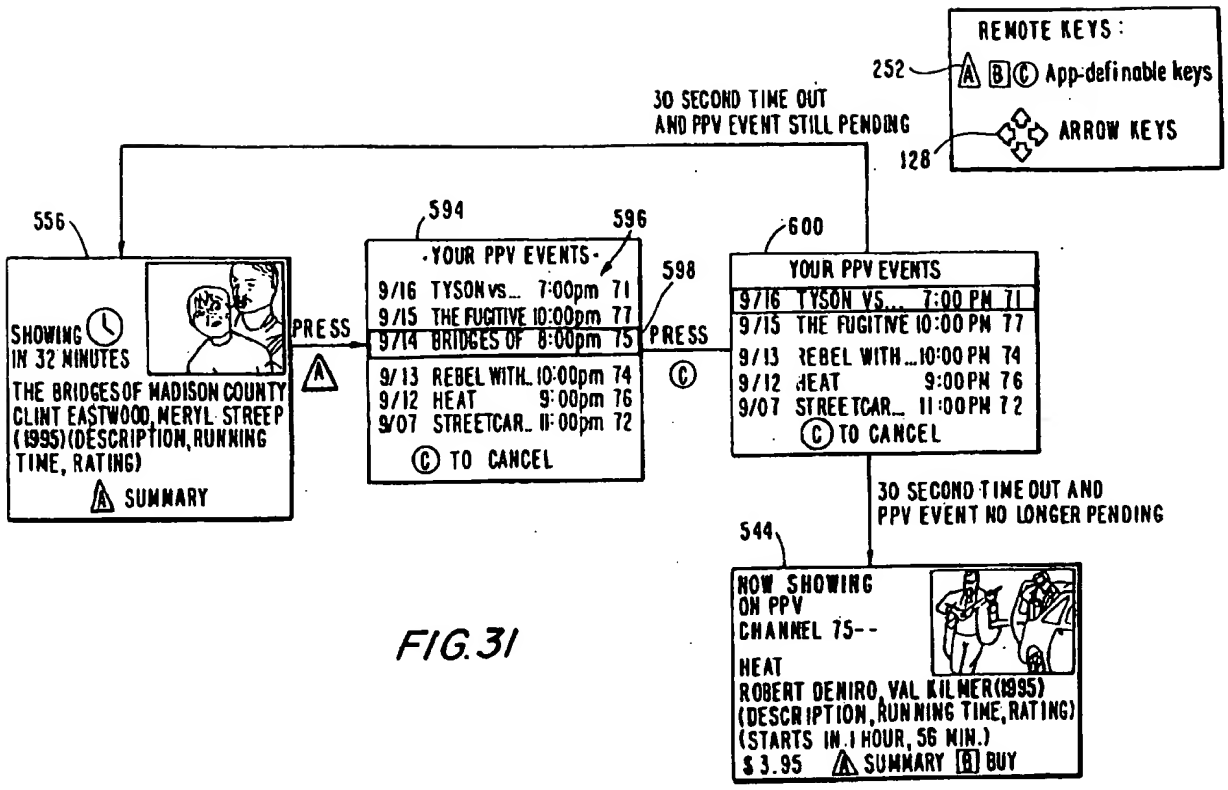

REMOTE KEYS:
252
A B C App-definable keys
ARROW KEYS
128
30 SECOND TIME OUT
AND PPV EVENT STILL PENDING
556
SHOWING IN 32 MINUTES
THE BRIDGES OF MADISON COUNTY
CLINT EASTWOOD, MERYL STREEP
(1995)(DESCRIPTION, RUNNING
TIME, RATING)
A SUMMARY
PRESS
A
594
596
·YOUR PPV EVENTS·
9/16 TYSON vs... 7:00pm 71
9/15 THE FUGITIVE 10:00pm 77
9/14 BRIDGES OF 8:00pm 75
9/13 REBEL WITH.. 10:00pm 74
9/12 HEAT 9:00pm 76
9/07 STREETCAR.. 11:00pm 72
C TO CANCEL
598
PRESS
C
600
YOUR PPV EVENTS
9/16 TYSON VS... 7:00 PM 71
9/15 THE FUGITIVE 10:00 PM 77
9/13 REBEL WITH... 10:00 PM 74
9/12 HEAT 9:00 PM 76
9/07 STREETCAR... 11:00 PM 72
C TO CANCEL
30 SECOND TIME OUT AND
PPV EVENT NO LONGER PENDING
544
NOW SHOWING
ON PPV
CHANNEL 75--
HEAT
ROBERT DENIRO, VAL KILMER(1995)
(DESCRIPTION, RUNNING TIME, RATING)
(STARTS IN 1 HOUR, 56 MIN.)
$3.95 A SUMMARY B BUY

FIG. 31

FIG. 32

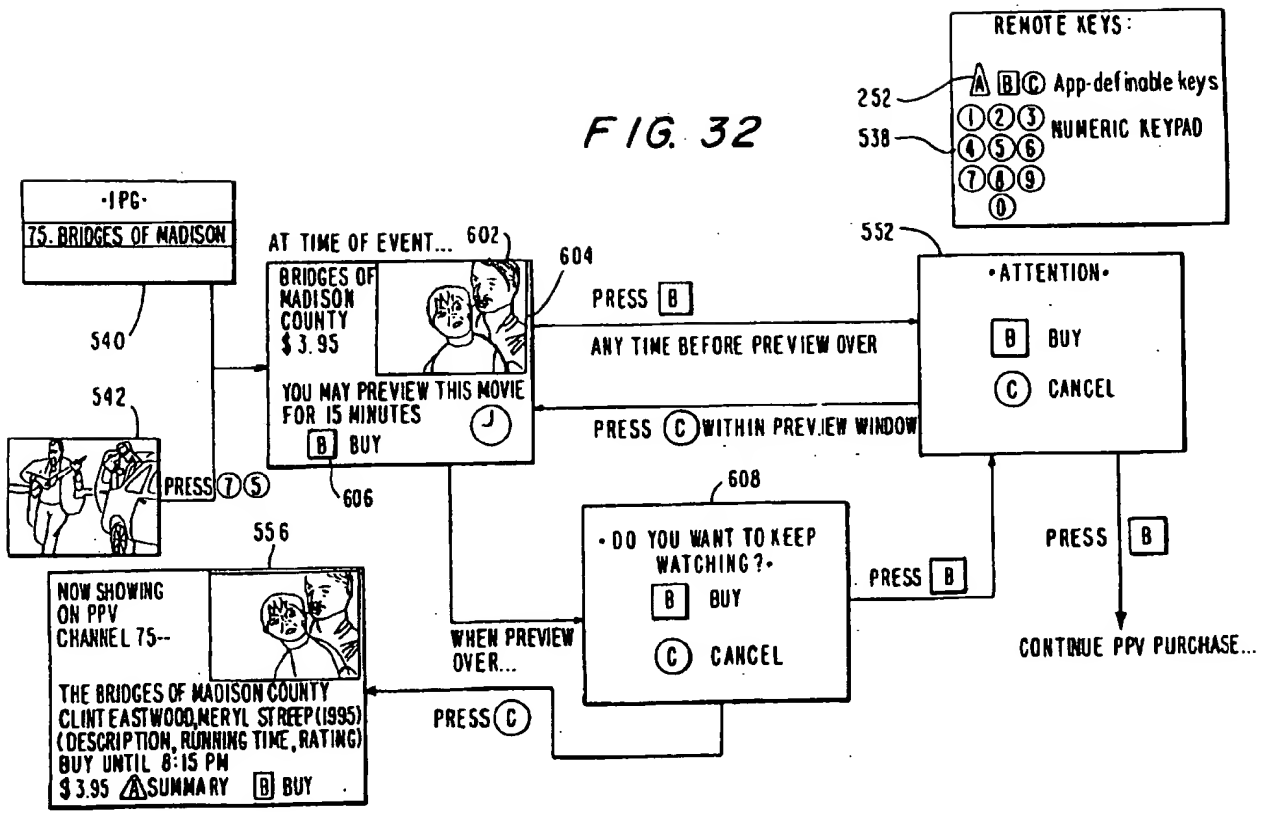

REMOTE KEYS:
A B C App-definable keys
1 2 3
4 5 6 NUMERIC KEYPAD
7 8 9
0
252
538
·IPG·
75. BRIDGES OF MADISON
540
542
PRESS 7 5
AT TIME OF EVENT... 602
BRIDGES OF MADISON COUNTY $3.95
604
YOU MAY PREVIEW THIS MOVIE FOR 15 MINUTES
B BUY
606
PRESS B
ANY TIME BEFORE PREVIEW OVER
PRESS C WITHIN PREVIEW WINDOW
552
·ATTENTION·
B BUY
C CANCEL
608
·DO YOU WANT TO KEEP WATCHING?·
B BUY
C CANCEL
PRESS B
PRESS B
CONTINUE PPV PURCHASE...
WHEN PREVIEW OVER...
PRESS C
556
NOW SHOWING ON PPV CHANNEL 75--
THE BRIDGES OF MADISON COUNTY
CLINT EASTWOOD, MERYL STREEP (1995)
(DESCRIPTION, RUNNING TIME, RATING)
BUY UNTIL 8:15 PM
$3.95 A SUMMARY B BUY

FIG. 33

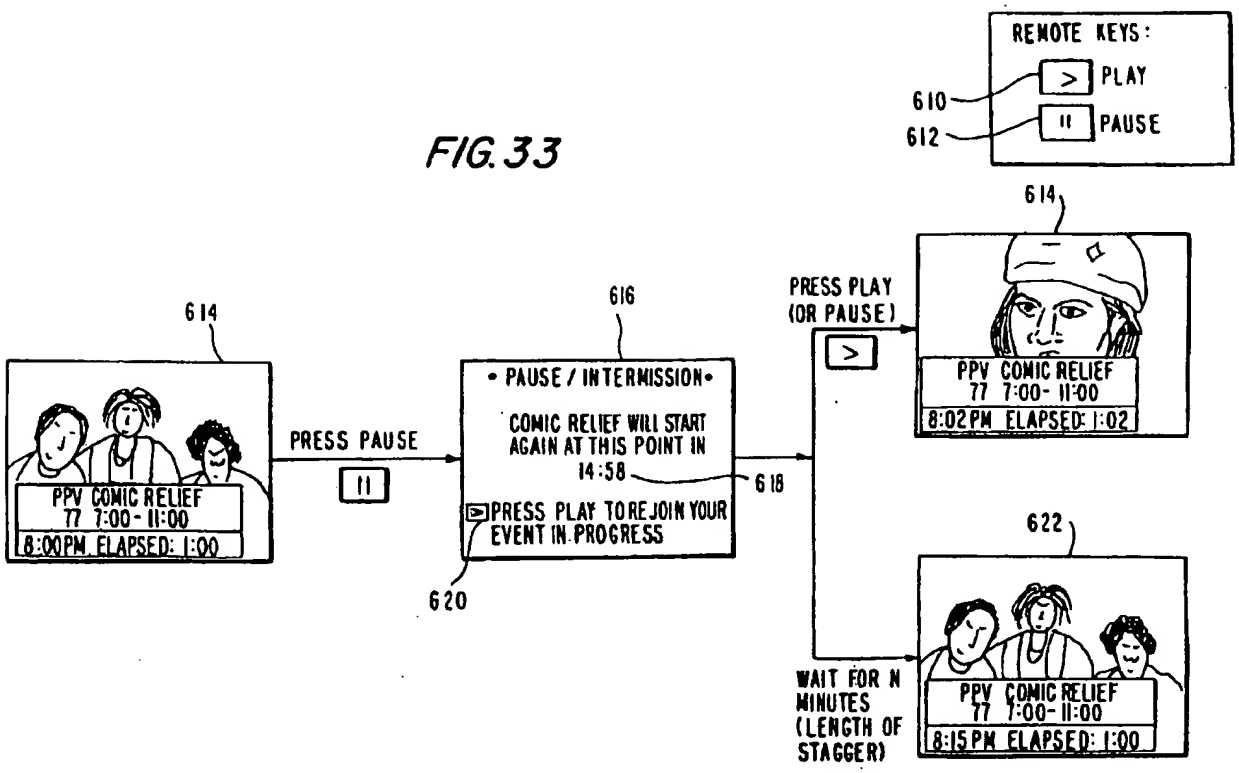
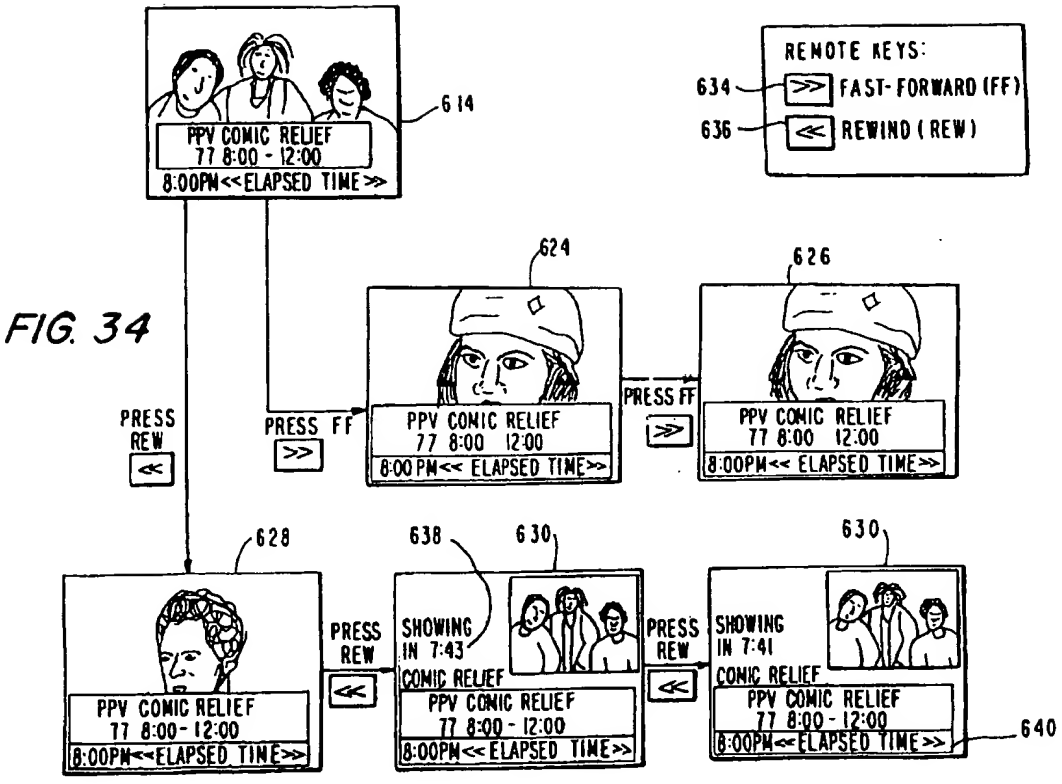

REMOTE KEYS:
PLAY
PAUSE
610
612
614
PPV COMIC RELIEF
77 7:00- 11:00
8:02PM ELAPSED: 1:02
PRESS PLAY
(OR PAUSE)
614
PPV COMIC RELIEF
77 7:00- 11:00
8:00PM ELAPSED: 1:00
PRESS PAUSE
616
• PAUSE / INTERMISSION•
COMIC RELIEF WILL START
AGAIN AT THIS POINT IN
14:58
618
PRESS PLAY TO REJOIN YOUR
EVENT IN PROGRESS
620
622
WAIT FOR N
MINUTES
(LENGTH OF
STAGGER)
PPV COMIC RELIEF
77 7:00- 11:00
8:15PM ELAPSED: 1:00

FIG. 34


REMOTE KEYS:
634
FAST-FORWARD (FF)
636
REWIND (REW)
614
PPV COMIC RELIEF
77 8:00 - 12:00
8:00PM<<ELAPSED TIME>>
624
626
PRESS REW
PRESS FF
628
638
630
SHOWING IN 7:43
COMIC RELIEF
SHOWING IN 7:41
640

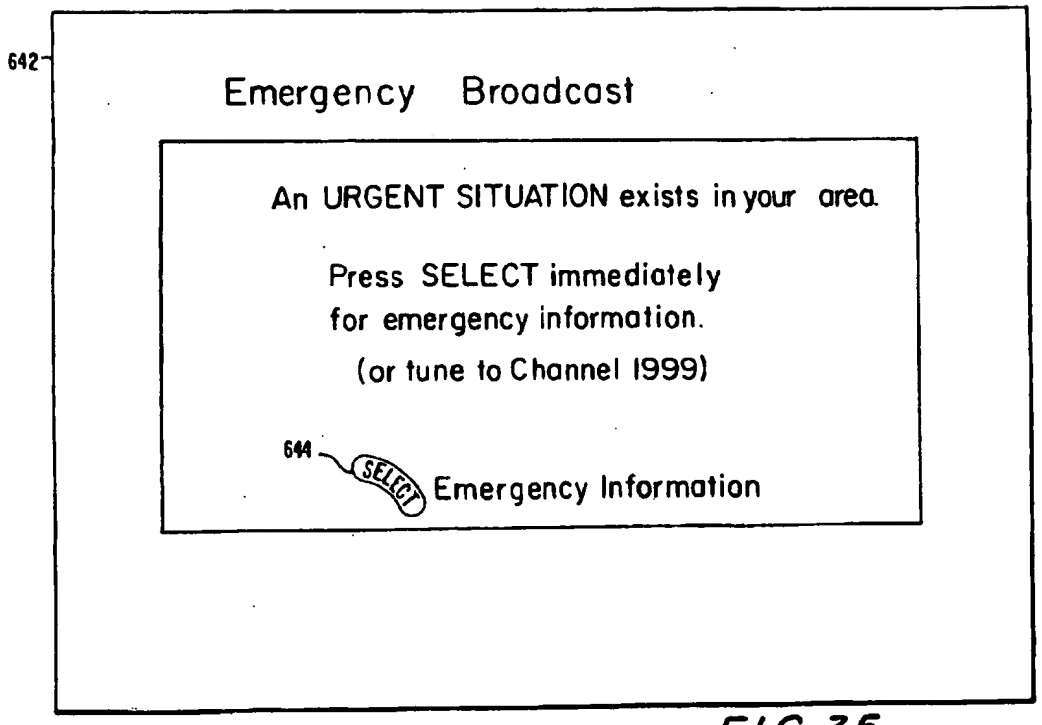

642
Emergency Broadcast
An URGENT SITUATION exists in your area.
Press SELECT immediately
for emergency information.
(or tune to Channel 1999)
644
SELECT
Emergency Information

FIG. 35

INTERACTIVE PROGRAM GUIDE FOR DESIGNATING INFORMATION ON AN INTERACTIVE PROGRAM GUIDE DISPLAY

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation of commonly assigned U.S. patent application Ser. No. 08/802,833, filed Feb. 19, 1997, now U.S. Pat. No. 5,850,218.

BACKGROUND OF THE INVENTION

This invention relates generally to television systems. More particularly, this invention relates to full service television systems that use advanced storage, communications, and processing techniques to provide a variety of television services including audio and audiovisual programming, advanced navigation controls, interactive program guides, Impulse Pay-Per-View activation, Near-Video-On-Demand programming, Video-On-Demand programming, advanced configuration controls, and online services.

With recent advances in storage, communication, and processing technologies, many present-day television systems are becoming antiquated. This is especially true of many cable television systems. Traditional methods of broadcasting television programs and services in such cable television systems suffer from an inability to deliver a high number of high quality television signals on a single coaxial cable. Many existing television systems also cannot provide the advanced television services desired by their subscribers, such as, for example, a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On-Demand programming, Video-On-Demand programming, and advanced configuration controls. Furthermore, most modern television systems have no provisions whatsoever for supplying services such as World Wide Web browsing, Internet E-Mail, and online services.

In view of the foregoing, it would be desirable to provide a full service television system capable of delivering a high number of high quality television signals.

It would also be desirable to provide a full service television system capable of using advanced communication techniques to deliver a high number of high quality television signals.

It would further be desirable to provide a full service television system capable of sustaining two-way communication between a cable service provider and a cable service subscriber.

It would even further be desirable to provide a full service television system capable of delivering advanced television services such as a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On-Demand programming, Video-On-Demand programming, and advanced configuration controls.

It would still further be desirable to provide a full service television system capable of delivering services such as World Wide Web browsing, Internet E-Mail, and online services.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a full service television system capable of delivering a high number of high quality television signals.

It is also an object of this invention to provide a full service television system capable of using advanced communication techniques to deliver a high number of high quality television signals.

It is a further object of this invention to provide a full service television system capable of sustaining two-way communication between a cable service provider and a cable service subscriber.

It is a still further object of this invention to provide a full service television system capable of delivering advanced television services such as a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On-Demand programming, Video-On-Demand programming, and advanced configuration controls.

It is an even further object of this invention to provide a full service television system capable of delivering services such as World Wide Web browsing, Internet E-Mail, and online services.

In accordance with these and other objects of the present invention, a full service television system is provided that includes digital and analog programs and services, an advanced communications network, and a fully programmable set-top terminal capable of implementing advanced television and online services.

In the preferred embodiments of the present invention, the full service television system is implemented as a cable television system. Although a cable television system is described herein, the present invention, and all of its features, may be implemented in other forms, such as, for example, a Direct Broadcast Satellite (DBS) system, a Multi-channel Multi-point Distribution System (MMDS), an Asymmetric Digital Subscriber Loop (ADSL) system, a Local Area Network (LAN) system, or a Wide Area Network (WAN) system.

Preferred implementations of the cable television system of the present invention include a cable headend, at least one fiber transport, at least one distribution hub, at least one hybrid fiber coax plant, and a plurality of set-top terminals. The cable headend provides programs, services, and overall system control of the cable television system. The fiber transports, distribution hubs, and hybrid fiber coax plants provide an advanced communication network for the cable television system. The set-top terminals provide interfaces, processing, and storage capability in a subscriber's home to facilitate the implementation of advanced television and online services.

To provide programs, services, and overall system control of the cable television system of the preferred embodiments of the present invention, the cable headend incorporates digital and analog satellite receivers, a broadcast cable gateway, integrated receiver decoders, analog scrambling and modulation, application and media servers, an addressable controller, a digital switch or multiplexer, and an interactive cable gateway. Although these elements will be described herein as distinct functions, each can be implemented as a portion of a single device, as a single device, or as a composition of devices.

Programs and services provided by the cable headend are supplied to the cable headend primarily through analog and digital satellite broadcasts and through digital data storage. The cable headend may also receive programs and services from sources such as, for example, analog off-air signals, digital off-air signals, and locally originated signals.

Analog and digital satellite broadcasts are received at the cable headend by a plurality of analog and digital satellite receivers. Integrated receiver decoders within the cable headend control the reception of the analog satellite

broadcasts, and analog scrambling and modulation converts the analog signals into a format suitable for transmission over the cable system's communication network. Similarly, a broadcast cable gateway within the cable headend controls the reception of the digital satellite broadcasts and converts the digital signals into a format suitable for transmission over the cable system's communication network.

Programs and services are also supplied to the cable headend through digitally stored data in application and media servers. Programs and services stored in the application and media servers are first transmitted to the cable system's communication network through a digital switch or multiplexer and then through an interactive cable gateway. The digital switch or multiplexer can be implemented through an Asynchronous Transfer Mode switch, a Digital Video Broadcast Asynchronous Serial Interface (DVB ASI), or other suitable means. The application servers can be connected directly to the digital switch or multiplexer, or can be connected to the digital switch or multiplexer via an intermediate network. The media servers, however, should preferably be connected to the digital switch or multiplexer directly because of the high bandwidth requirements of the media servers and the limited bandwidth capabilities of present day networks. Programs and services transmitted through the digital switch or multiplexer from the application and media servers are converted by the interactive cable gateway to a format suitable for transmission in the cable system's communication network. By connecting the application and media servers to the interactive cable gateway through the digital switch or multiplexer, a cable system operator can add new application and media servers to the cable television system as needed.

Overall system control is provided by the cable headend primarily through an addressable controller. The functions performed by the addressable controller can include, for example, control of all equipment interaction at the cable headend, management of the cable television system's communication network, control of all equipment located in the system's communication network, configuration and management of set-top terminals (preferably both those of the present invention and those that may later be introduced into the marketplace), operational control of the distribution hubs, operational control of the interactive cable gateway, and distribution control of programs and services from the integrated receiver decoders, broadcast cable gateway, application servers, and media servers to the set-top terminals.

The communication network of the cable television systems of the preferred embodiments of the present invention includes at least one fiber transport, at least one distribution hub, and at least one hybrid fiber coax plant. The communication network preferably includes analog channels with vertical blanking interval (VBI) signals, forward application transport (FAT) channels, forward data channels (FDC), and reverse data channels (RDC). Analog channels with VBI signals maintain downward compatibility with existing cable television equipment. FAT channels provide set-top terminals with compressed digital content such as, for example, video, audio, applications, control message, and broadcast data. Forward data channels carry to the set-top terminals out-of-band Internet protocol (IP) datagrams containing messages regarding, for example, conditional access, entitlement, broadcast data, network management, application downloads, variable bit-rate (VBR) downloads, external device data services, or general matters. Furthermore, all interactive program guide data is carried to the set-top terminals exclusively over the out-of-band forward data channels. Reverse data channels carry IP datagram messages from the set-top terminals to equipment within the cable headend. These messages can relate to, for example, network management, external device data services, program/service control and activation, or general matters.

The fiber transports carry signals between the cable headend and the distribution hubs and are preferably each physically configured in a ring connecting typically five distribution hubs to the cable headend. Each of the fiber transports includes a bundle of at least one fiber optic cable, at least one of which is used by each distribution hub on the physical ring of each fiber transport. By using selected fiber optic cables within the fiber transport's bundle, the distribution hubs may be connected to the cable headend either through adjacent hubs in a logical "ring" configuration, directly to the headend in a logical "star" configuration, or in any other logical configuration.

The distribution hubs comprise a plurality of data channel gateways, each of which receives and transmits data messages between the cable headend and the set-top terminals. The data channel gateways provide routing functions, modulation functions on the signals to the set-top terminals, and demodulation functions on the signals from the set-top terminals. The routing, modulation, and demodulation functions performed by the data channel gateways are all controllable by the addressable controller within the cable headend.

The hybrid fiber coax plants connect the distribution hubs to the set-top terminals and each includes fiber optic cable, a node, and a plurality of coaxial cables. The node in each hybrid fiber coax plant converts optical signals to electrical signals and electrical signals to optical signals such that two-way communication is maintained over the fiber optic and coaxial cables connecting the distribution hubs and set-top terminals.

The digital and analog programs and services furnished by the cable headend are presented to cable subscribers by set-top terminals within their homes. In the preferred embodiments of the present invention, the set-top terminals each include a central processing unit, memory, a memory management unit, communications circuitry, I/O control circuitry, and audio and video output circuitry. Each set-top terminal is controlled by the central processing unit which executes operating system and application software stored within memory. The memory management unit simplifies and oversees the interaction between the central processing unit and memory. Communication circuitry in the set-top terminal receives, demodulates, decrypts, decodes, and descrambles programs and services transmitted by the cable headend. Additionally, the communication circuitry also controls the two-way digital data transmissions between the headend and the set-top terminal. Input/output (I/O) control circuitry controls subscriber interaction with the set-top terminal through a keypad, an LED display, and a remote control. The I/O control circuitry also interfaces the set-top terminal with an accessories bus and external equipment (e.g., via an I/R transmitter), and is compatible with known interfaces, such as, for example, Ethernet 10-base-T, P1394, and SPDIF. Audio and video control circuitry in each set-top terminal provides graphics generation, audio synthesis, and real-time -digital video processing, and generates the outputs necessary to interface the set-top terminal with a subscriber's home audio and video system. These audio and video outputs can include, for example, AC-3 audio, baseband audio, RF video, S-Video, and baseband video outputs.

In the preferred embodiments of the present invention, application software within the set-top terminal provides the

advanced cable services desired by many cable subscribers. These services include a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On Demand programming, Video-On-Demand programming, and advanced configuration controls. Additionally, because the set-top terminal is upgradable via software downloads from the cable headend, new services can be added to the set-top terminal as they become available.

The comprehensive channel navigation controls provided by the application software of the set-top terminal enable a subscriber to more easily navigate through the abundance of programming and services that are available in the preferred embodiments of the present invention. For example, a program information banner can be displayed whenever a subscriber changes channels to identify the program currently being displayed on the selected channel. This banner can include the following: the channel's call sign, number, and logo; the program's name, running time, and elapsed time; the current time; a brief description of the program; information regarding the next program on that channel; or any other information that may be of interest to the subscriber.

The navigation controls of the preferred embodiments of the present invention provide a channel selection function that includes a plurality of tables that cross reference channel numbers with the type, source, parameters, and description of the various television services (e.g., audio and video programming and online services) provided by the cable system. These tables create levels of control, transparent to the subscriber, that allow the set-top terminal to identify the parameters and software needed to activate the program or service associated with a selected channel number. For example, if a subscriber selects channel **10**, which is associated with an E-mail service, the set-top terminal accesses the cross-reference tables to identify the type and source of the television service associated with channel **10**. The set-top terminal then obtains from the tables any necessary parameters and executes the appropriate E-mail software to activate the selected service. Thus, rather than just map channel numbers to analog broadcast video frequencies as in traditional cable systems, these tables allow channel numbers to be mapped to other sources of data, such as, for example, MPEG video, VBI, IP, and ROM.

Furthermore, unlike traditional cable systems in which channel numbers are fixed to analog broadcast frequencies, these cross-reference tables allow television services to be arranged in any channel number order, regardless of how they are transmitted by the cable system to the set-top terminal. For example, a channel table can be configured to associate channel **4** with video service **3** provided by video source **2** or, alternatively, channel **4** can be associated with music service **12** provided by music source **8**. Once a set-top terminal channel number is associated with a particular service, the association is maintained even if the cable provider reassigns the cable channel numbers over which the television services are transmitted.

The preferred embodiments of the present invention also provide channel setting controls which enable a subscriber to fully configure the set-top terminal to operate as desired. For example, the subscriber can assign channels to a favorite channel list; block channels based on channel number, time, program rating, genre, etc.; set timers to record a particular program; turn the set-top terminal on or off at a particular time; or remind the subscriber that a particular program is on or that a tape has to be put in an attached video cassette recorder (VCR).

A browse feature is also provided by the comprehensive navigation controls in the preferred embodiments of the present invention. The browse feature presents a banner that can identify other programs or services that are, were, or will be available for viewing on other channels. Similar to the program information banner described previously, the browse banner can include the following: a channel's call sign, number, and logo; a program's name, running time, and elapsed time; the current time; a brief description of the current program; information regarding a program following the browse program; or any other information that may be of interest to a subscriber.

An interactive program guide within the set-top terminal of the preferred embodiments of the present invention further allows the subscriber to easily operate the set-top terminal and navigate through the abundance of programs and services available in the cable television system. This interactive program guide can include any of at least three main modes: a time mode, a theme mode, and a title mode.

In the time mode, program information is displayed in a grid arrangement with rows preferably corresponding to channel numbers, and columns preferably corresponding to times. By navigating through this grid, a subscriber can identify and review information regarding programs that were, are, or will be available for viewing.

The theme mode of the present invention displays program information of programs that were, are, or will be available for viewing based on a subscriber-selected theme category. Once a theme category has been selected, all programs within that theme are displayed to the subscriber. In some embodiments of the present invention, in addition to scrolling through programs corresponding to a selected theme, a subscriber can also scroll to other themes after reaching the end of the list of programs corresponding to the selected theme.

Similar to the theme mode, the title mode lists and displays information regarding programs available for viewing based on the titles of the programs. Once a first letter is selected, all programs having titles beginning with that letter that were, are, or will be available for viewing are displayed to the subscriber. As with themes, in some embodiments of the present invention, a subscriber is not limited to viewing only those programs with titles beginning with the selected letter, but rather the subscriber may scroll to program titles beginning with other letters once an end of the program titles beginning with the selected letter has been reached.

All modes of the interactive program guide of the preferred embodiments of the present invention can include a highlighted channel banner, a highlighted program summary, a program viewing window, and mode indicators. The highlighted channel banner preferably indicates the call sign, channel number, and channel logo of the channel highlighted in the interactive program guide display. The highlighted program summary preferably indicates the title, running time, description, and characteristics of the program highlighted in the interactive program guide display. The program viewing window can display, for example, any of the following: the program being viewed prior to entering the interactive program guide, a program selected from the interactive program guide, or a program selected at the headend. The content of the program in the program viewing window can include any of the programs or services which can be displayed by the set-top terminal. The program viewing window can also include a time and channel banner indicating the current time and the channel being displayed in the program viewing window. The mode indicators can

indicate the current mode of the interactive program guide and how to activate other available program guide modes.

The interactive program guide of the preferred embodiments of the present invention also facilitates rapid navigation to programs selected by a subscriber. Once the subscriber has found a desired program in the interactive program guide, the subscriber can, by pressing a single key, switch to the program if it is currently being transmitted, set a timer to remind the subscriber of its scheduled transmission, or record the program, either now if currently transmitted or at its scheduled transmission time.

Impulse Pay-Per-View (IPPV) program purchasing is also facilitated in the preferred embodiments of the present invention. Through Impulse Pay-Per-View, a subscriber can request a Pay-Per-View event from the set-top terminal's keypad or remote control. Upon the subscriber selecting an IPPV program, which can be through either the interactive program guide, manual channel selection, or setting of a recording timer, the set-top terminal automatically identifies channels and programs which are IPPV, queries whether the subscriber would like to purchase the selected IPPV program, and authorizes the purchase if the subscriber so indicates. The preferred embodiments of the present invention also allow a subscriber to view summaries of past and currently scheduled IPPV purchases, and to cancel currently scheduled purchases. Additionally, the IPPV features of the preferred embodiments of present invention provide free preview screening of IPPV events, countdown timers to the start of an IPPV event, and automatic reminders if the subscriber has changed channels between the time of ordering and the start time of the IPPV event.

Near-Video-On-Demand (NVOD) can also be implemented in the preferred embodiments of the present invention. NVOD programming transmits each NVOD program from a plurality of sources, each source transmitting the same NVOD program at a fixed time period out of phase with the others. Upon a request to view an NVOD program, the set-top terminal displays on an NVOD channel the source that will next begin transmitting the selected NVOD program based on when the subscriber chooses to view the program.

NVOD programming can simulate the VCR functions of pausing, fast forwarding, and rewinding. This is accomplished by switching the NVOD channel to another NVOD program source. For example, to pause an NVOD program, the set-top terminal displays a pause "barker" (e.g., on-screen message) for the time period between consecutive out-of-phase transmissions of the NVOD program. Once the time period has passed, the set-top terminal switches to the source that began transmitting the program one time period after the previously displayed source's transmission. The NVOD program thus resumes at the point where paused and appears to the subscriber to have been paused by that time period. Similarly, fast forwarding and rewinding are accomplished by switching directly to another NVOD program source. For example, fast forwarding switches to a source that began transmitting the program before the currently viewed transmission, and rewinding switches to a source that began transmitting the program after the currently viewed transmission. By switching to a different NVOD program source, the NVOD program appears to have jumped by the time period between transmissions.

Video-On-Demand (VOD) programming can also be implemented in the preferred embodiments of the present invention. VOD is facilitated primarily by the media servers' ability to deliver high-speed digital data to subscribers' set-top terminals. Upon a subscriber's request to view a VOD event, a media server capable of delivering the VOD event begins digitally transmitting the program to the subscriber's set-top terminal. Unlike traditional broadcasts, this transmission is typically received only by the subscriber who requested the VOD event. A subscriber can therefore view the program at any time, and can also pause, fast forward, or rewind the program being transmitted.

Finally, the preferred embodiments of the present invention also allow messages to be transmitted to one or more subscribers. These messages can be sent to all subscribers (e.g., an emergency broadcast message) or to only one subscriber (e.g., an unpaid balance message). This message system can also send messages from one party within a household to another (e.g., an instruction by a parent to a child) or from one household to another. Thus a local messaging system within the cable system's community can be established. Additionally, these messages can be configured to activate a service at a subscriber's set-top terminal. For example, a set-top terminal can be automatically turned on to display an emergency news broadcast upon receipt of a message from the headend. Thus a subscriber can be alerted by the set-top terminal at any time, regardless of whether the set-top terminal is on or not.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the present invention will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

FIG. **1** is a block diagram of a cable television system of a preferred embodiment of the present invention;

FIG. **2** is a schematic diagram of a cable television system of a preferred embodiment of the present invention;

FIG. **3** is a block diagram of a set-top terminal of a preferred embodiment of the present invention;

FIG. **4** is a flow diagram of a channel navigation function of a set-top terminal of a preferred embodiment of the present invention;

FIG. **5** is a data structure diagram illustrating a channel selection function of a preferred embodiment of the present invention;

FIGS. **6–7** are flow diagrams illustrating a browse function of a set-top terminal of a preferred embodiment of the present invention;

FIG. **8** is layout diagram illustrating a browse banner of a preferred embodiment of the present invention;

FIGS. **9–13** are flow diagrams illustrating channel and general setting functions of a set-top terminal of a preferred embodiment of the present invention;

FIG. **14** is an illustrative screen display of a general setting menu of a set-top terminal of a preferred embodiment of the present invention;

FIG. **15** is a flow diagram illustrating a general setting function of a set-top terminal of a preferred embodiment of the present invention;

FIGS. **16–17** are illustrative screen displays of the time mode of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIG. **18** is a flow diagram illustrating entry, navigation, and tuning within the time mode of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIG. 19 is a flow diagram illustrating switching modes within an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 20–21 are illustrative screen displays of a theme mode of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 22–23 are illustrative screen displays of a title mode of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 24–27 are flow diagrams illustrating the operation of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIG. 28 is a flow diagram illustrating an Impulse Pay-Per-View function of a set-top terminal of a preferred embodiment of the present invention;

FIG. 29 is an illustrative screen display of an Impulse Pay-Per-View barker of an Impulse Pay-Per-View function of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 30–32 are flow diagrams illustrating the operation of an Impulse Pay-Per-View function of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 33–34 are flow diagrams illustrating the operation of a Near-Video-On-Demand function of a set-top terminal of a preferred embodiment of the present invention; and

FIG. 35 is an illustrative screen display of a messaging function of a set-top terminal of a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

A cable television system 1 of a preferred embodiment of the present invention is shown in FIG. 1. Cable system 1 includes five primary components: a headend 2; at least one fiber transport 3; at least one distribution hub 4; at least one hybrid fiber coax plant 5; and a plurality of set-top terminals 6, typically located in the homes of subscribers. Headend 2 is the primary source of programs, services, and control of cable system 1. Programs, services, and control signals are delivered to subscribers' set-top terminals 6 from headend 2 by transmitting signals through fiber transport 3, distribution hub 4, and hybrid fiber coax plant 5. These transmissions can be in the form of broadcasts to all set-top terminals, narrowcasts to a group of set-top terminals, multicasts to a list of particular set-top terminals, or unicasts to a single set-top terminal. The present invention can be implemented as a one-way cable television system in which signals are only transmitted from headend 2 to set-top terminals 6, or alternatively, in a preferred embodiment, can be implemented as a two-way interactive cable television system. Subscribers interact with the programs and services provided by headend 2 by transmitting signals from set-top terminals 6 through hybrid fiber coax 5, distribution hub 4, and fiber transport 3 to headend 2.

To provide the programs, services, and control of cable system 1, headend 2 includes a plurality of digital satellite receivers 10, a broadcast cable gateway (BCG) 11, a plurality of analog satellite receivers 12, a plurality of integrated receiver decoders (IRD) 13, analog scrambling and modulation circuitry 20, an addressable controller (AC) 14, a plurality of application servers 15, a plurality of media servers 16, a digital switch or multiplexer 17, and an interactive cable gateway (ICG) 18. Although each of these headend 2 elements are described as single functions, each can be implemented as part of a single device, as a single device, or as a plurality of devices.

The programs and services generated by headend 2 are received from four primary sources: analog satellite transmissions from analog service providers, digital satellite transmissions from digital service providers, application programs and services on application servers 15, and media programs and services on media servers 16. Programs and services can also be received at headend 2 from other sources, such as, for example, analog off-air signals, digital off-air signals, and locally originated signals. Analog and digital satellite transmissions typically provide the traditional forms of television broadcast programs and information services. Application servers typically provide, for example, executable code and data for application specific services such as database services, network management services, transactional electronic commerce services, system administration console services, application specific services (such as stock ticker, sports ticker, weather, and interactive program guide data), resource management services, connection management services, subscriber care services, billing services, operation system services, and object management services. Media servers provide time-critical media assets, such as, for example, MPEG-2 encoded video and audio, MPEG-2 encoded still images, bit-mapped graphic images, PCM digital audio, three dimensional graphic objects, application programs, and application data files. Although specific examples of programs and services and the sources that provide them (such as analog and digital satellite transmissions, application servers, and media servers) are given herein, other programs and services, and programs and services from other sources, can be provided to cable system 1 without departing from the spirit and scope of the present invention.

To provide this multitude of programs and services to a subscriber's home on a single coaxial cable, these signals are preferably modulated onto a plurality of 6 MHZ frequency division multiplexed (FDM) channels in the RF spectrum from 5 MHZ through 860 MHZ. More specifically, the 6 MHZ FDM channels in the present invention can be used to carry analog channels with vertical blanking interval (VBI) signals, forward application transport (FAT) channels, forward data channels (FDC), and reverse data channels (RDC). In one embodiment of the present invention, analog channels are in the frequency range of 50 to 500 MHZ, FAT channels are in the frequency range of 500 to 750 MHZ, and FDCs and RDCs are in the frequency ranges of 5 to 40 MHZ and 70 to 130 MHZ, respectively. Although values for the bandwidth, upper limits, and lower limits of these channels are given herein, these values can be altered to suit the individual needs and capabilities of any system in which the present invention is implemented without departing from the spirit and scope of the present invention. For example, 1 MHZ FDM channels can be implemented wherein each of the analog channels, FAT channels, forward data channels, and reverse data channels use different sections of the RF spectrum.

Analog programs and services are received from satellite transmissions in the preferred embodiments of the present invention by analog satellite receivers 12, integrated receiver decoders 13, and analog scrambling and modulation circuitry 20. Analog satellite receivers 12 typically receive the satellite transmissions from the analog service providers in a modulated and scrambled NTSC format. Integrated receiver decoders 13 demodulate and descramble the satellite signals into NTSC signals, and then analog scrambling and modulation circuitry 20 scrambles (using the cable system's scrambling method, if desired) and modulates the NTSC signals onto an analog 6 MHZ FDM channel. The

FDM modulation frequencies and scrambling techniques used for the NTSC signals are preferably selected to maintain downward compatibility with analog set-top terminals that may be used with the present invention. The demodulation, descrambling, scrambling, and modulation functions performed by integrated receiver decoders **13** and analog scrambling and modulation circuitry **20** can alternatively be performed by other dedicated devices, such as, for example, satellite receivers, satellite decoders, NTSC scramblers, and NTSC modulators.

Digital services are received from satellite transmissions by digital satellite receivers **10**. The signals received by digital satellite receivers **10** typically arrive in quadrature phase shift key (QPSK) modulated, encrypted MPEG-2 transport stream format. Once the satellite transmissions have been received by the digital satellite receivers, broadcast cable gateway (BCG) **11** converts the transmissions signals for transmission over the cable system's communication network under the control of addressable controller **14** broadcast cable gateway **11** demodulates, applies forward error correction (FEC), if desired, and decrypts the satellite transmission to recover an MPEG-2 transport stream. The MPEG-2 transport stream may then be manipulated by BCG **11** to remove unwanted programs from the stream to form an MPEG-2 payload. BCG **11** then encrypts the payload (if desired) and modulates it onto a forward application transport (FAT) 6 MHZ FDM channel. The modulation of FAT channels is preferably 64 or 256 quadrature amplitude modulation (QAM), which enables the channels to carry digital data at rates typically in the range of 27 to 38 Mbps, respectively. By using MPEG-2 payloads, the present invention provides an increase in the number of programs and services that can be transmitted on a 6 MHZ channel over that available with analog technology by digitally compressing and combining a plurality of programs and services into a single MPEG-2 payload.

Application and media programs and services are provided by application and media servers **15** and **16** under the control of addressable controller **14** through digital switch or multiplexer **17**, interactive cable gateway **18**, and data channel gateways **19** in distribution hubs **4**. The programs and services provided by application and media servers **15** and **16** are preferably provided in MPEG-2 transport stream format. Addressable controller **14** may oversee the distribution of programs and services by servers **15** and **16** by processing requests for programs and services from set-top terminals **6**, instructing the servers when, where, and how to deliver a requested program or service, and directing the programs and services through the digital switch or multiplexer to the interactive cable gateway and data channel gateways in the distribution hubs.

Digital switch or multiplexer **17** connects servers **15** and **16** to addressable controller **14**, to interactive cable gateway **18**, and to data channel gateways **19** in distribution hubs **4**. Because the programs and services provided by application servers **15** typically do not require high bandwidth, these servers can be connected to digital switch or multiplexer **17** directly (as shown) or via intermediate networks. Media servers **16**, however, do require a great deal of bandwidth and accordingly should be connected to digital switch or multiplexer **17** or interactive cable gateway **18** directly until intermediate networks with sufficient bandwidth become available. Furthermore, to achieve their high bandwidth requirement, media servers **16** should incorporate storage devices having interfaces with speeds of at least SCSI Fast and SCSI Wide interfaces, and preferably speeds of Ultra SCSI and fiber channel interfaces.

Interactive cable gateway (ICG) **18** processes the servers' signals so they can be transmitted over the cable system's communication network. Signals received at ICG **18**, either through digital switch or multiplexer **17** or from servers **15** or **16** directly, are optionally encrypted, optionally subjected to forward error correction (FEC), and modulated onto a 6 MHZ FAT channel using 64 or 256 quadrature amplitude modulation (QAM).

The analog channels, forward application transport channels, forward data channels, and reverse data channels are transmitted between the cable headend and the set-top terminals over the cable systems' communication network. As shown in FIG. **2**, this network comprises at least one fiber transport **3**, at least one distribution hub **4**, and at least one hybrid fiber coax plant **5**.

Each fiber transport **3** connects headend **2** to at least one distribution hub **4**. Typically fiber transport **3** is physically configured as a ring of bundled fiber optic cables. In this configuration, six cables in the bundle of each fiber transport **3** are typically dedicated to each hub **4** on the ring, and each hub **4** is typically within twenty miles of headend **2**. For those hubs **4** that are more than a limiting distance (e.g., more than 20 miles) from headend **2**, an intermediate distribution hub **4** may be needed to retransmit the signals in fiber transport **3**.

By selecting particular fiber optic cables within the bundle of fiber transports **3**, the distribution hubs can be connected to headend **2** through adjacent hubs in a logical "ring" configuration, or directly to headend **2** in a logical "star" configuration. Alternatively, other logical configurations can be used. However, an advantage of the ring configuration is that no distribution hub **4** is cut off from headend **2** by a single break in fiber transport **3**.

Hybrid fiber coax plants **5** connect distribution hubs **4** to set-top terminals **6**. In a preferred embodiment, hybrid fiber coax plants **5** include a plurality of fiber optic cables **25**, a plurality of nodes **26**, and a plurality of coaxial cables **27**. A plurality of radio frequency (RF) amplifiers (not shown) may also be required at various locations throughout coaxial cables **27** to compensate for losses that occur when the coaxial cable is split to connect each set top terminal. Nodes **26** convert the optical signals in fiber optic cables **25** generated by the distribution hub **4** into electrical signals for transmission on coaxial cables **27** to set-top terminals **6**. Return signals from set-top terminals **6** on coaxial cables **27** are converted to optical signals by nodes **26** for transmission in fiber optic cable **27** to distribution hubs **4**.

As shown in FIG. **1**, each distribution hub **4** comprises a plurality of data channel gateways **19** that support the forward and reverse data channels between headend **2** and set-top terminals **6**. In the preferred embodiment of the present invention, the signals in the forward and reverse data channels between headend **2** and data channel gateways **19** are Internet protocol datagrams. Between data channel gateways **19** and set-top terminals **6**, these Internet protocol datagrams may be encrypted or decrypted, as desired, and QPSK modulated or demodulated. Accordingly, data channel gateways **19** can include routing, encryption, decryption, QPSK modulation, and QPSK demodulation functions.

One embodiment of set-top terminal **6** constructed in accordance with the present invention is shown in FIG. **3**. Set-top terminal **6** includes the following: a central processing unit (CPU) **30**, a memory management unit **31**, memory **32** comprising NVRAM, DRAM, flash read only memory (ROM), and ROM, an MPEG-2 decompression unit **33**, an A/D converter **34**, an IP router **35**, a security unit **36**, a QAM

64/256 demodulator **37**, an NTSC decoder **38**, a QPSK demodulate unit **39**, a QPSK modulate unit **40**, an in-band tuner **41**, an out-of-band tuner **42**, an out-of-band transmitter **43**, an NTSC encoder **44**, an RF modulator **61**, an RF output **45**, an S-Video output **47**, a baseband video output **48**, a graphics subsystem **46**, an audio subsystem **49**, an AC-3 audio output **50**, a baseband audio output **51**, an I/O subsystem **52**, a keypad **53**, an LED display **54**, an IR receiver **55**, an IR transmitter **56**, an accessories bus interface **57**, and a 10-base-T interface **58**.

Controlling the operation of set-top terminal **6** is central processing unit **30**. Preferably CPU **30** is a processor that can support **32** bit arithmetic and logical operations, operate at speeds of at least **25** MIPS, and support a system of dynamically prioritizable hardware and software interrupts. An example of a suitable processor for CPU **30** is the SUN Micro-Systems micro-SPARC core. CPU **30** executes instructions stored in memory **32** under the control of an operating system such as the PowerTV Operating System by PowerTV, Inc., of Cupertino, Calif. CPU **30** accesses memory **32** through memory management unit (MMU) **31**. MMU **31** provides memory protection for application processes and the kernel, and provides a flat address space for subscriber processes.

Memory **32** comprises non-volatile random access memory (NVRAM), dynamic random access memory (DRAM), flash read only memory (ROM), and read only memory (ROM). NVRAM is used primarily for the storage of subscriber settings and set-top terminal configuration settings, such as, for example, parental control codes, favorite channel line ups, set-top terminal setups, channel maps, authorization tables, and forward data channel address assignments. At least 2K bytes of NVRAM should be provided in memory **32**. Dynamic RAM is used for most application and operating system storage requirements, such as, for example, the stack, heap, graphics, interactive program guide data, channel map, VCR codes, marketing data, and usage data, and functions such as MPEG-2 video decompression, AC-3 audio decoding, and video manipulation. At least 3M bytes of dynamic RAM should be provided in memory **32**. Flash ROM is used primarily for the storage of resident application software, as well as patches to the operating system and application software which are downloaded to the set-top terminal from the headend after the set-top terminal has been deployed in the subscriber's home. At least 1M byte of flash ROM should be provided in memory **32**. ROM is used primarily for the storage of the operating system. At least 1M byte of read only memory should be provided in memory **32**. Although specific purposes for the NVRAM, DRAM, flash ROM, and ROM are illustrated herein, these memory elements can be used for purposes not listed and for purposes listed as corresponding to other elements without departing from the spirit and scope of the present invention.

Frequency division multiplexed (FDM) signals from headend **2** are initially received from hybrid fiber coax plant **5**. In-band tuner **41** receives programs and services transmitted to the set-top terminal on analog channels and forward application transport channels. These programs and services include analog programs and services from analog satellite broadcasts, digital programs and services from digital satellite broadcasts, some digital programs and services from application servers, and digital programs and services from media servers. NTSC decoder **38** receives the analog programs and services from in-band tuner **41** and produces NTSC baseband signals. QAM 64/256 demodulator **37** receives the digital programs and services from in-band tuner **41** and demodulates the signal into MPEG-2 payloads. Out-of-band tuner **42** receives only incoming IP datagram messages from headend **2** on the forward data channel. Messages transmitted from the headend to the set-top terminals in Internet protocol datagrams on the forward data channel include interactive program guide data messages as well as other data and control messages. Messages received by out-of-band tuner **42** are QPSK demodulated by QPSK demodulator **39** to reveal the IP datagrams. The analog NTSC baseband signals, the digital MPEG-2 payloads, and the digital IP datagrams are descrambled (if necessary), decrypted (if necessary), and screened by security unit **36**. Additionally, security unit **36** provides encryption, key management, authentication, and secure transaction functions, and prevents downloading of viruses by authenticating trusted sources, vandalism of software, theft of services, falsified orders by using electronic signatures, tampering with the set-top terminal, and direct cloning or remanufacturing of the set-top terminal.

After descrambling, decryption, and screening by security unit **36**, the baseband signals, MPEG-2 payloads, and IP datagrams are passed on to the analogto-digital converter **34**, MPEG-2 decompress unit **33**, and IP router **35**. As their names imply, analog-to-digital converter **34** converts the NTSC baseband signals to digital signals; MPEG-2 decompress unit **33** decompresses the MPEG-2 payloads; and IP router **35** routes the IP datagrams toward their ultimate destination.

Outgoing IP datagram messages are also processed by IP router **35**. After routing the outgoing IP datagrams, security unit **36** screens and encrypts the IP datagrams (if necessary). The IP datagrams are then QPSK modulated by QPSK modulator **40** and transmitted to hybrid fiber coax plant **5** by out-of-band transmitter **43**.

The video and audio outputs of set-top terminal **6** are generated by graphics subsystem **46**, audio subsystem **49**, NTSC encoder **44**, and RF modulator **61**. Graphic subsystem **46** produces graphic images and scales MPEG-2 and NTSC video. NTSC encoder **44** generates S-Video output **47** and baseband video output **48** from digitized MPEG-2 and NTSC video. Audio subsystem **49** produces the audio outputs for set-top terminal **6** including AC-3 audio output **50** and baseband audio output **51**. RF modulator **61** generates NTSC RF output **45** necessary to drive a television without S-Video or baseband inputs from signals received from NTSC encoder **44** and audio subsystem **49**.

I/O subsystem **52** controls input and output functions and the 10-base-T computer interface for set-top terminal **6**. As shown in FIG. **3**, I/O subsystem **52** receives inputs from keypad **53**, I/R receiver **55**, accessories bus **57**, and 10-base-T interface **58**. I/O subsystem **52** also produces outputs to LED display **54**, I/R transmitter **56**, accessories bus **57**, and 10-base-T interface **58**. Keypad **53** enables the subscriber to control set-top terminal **6** without remote control **59**. LED display **54** provides a numeric display for channel or time indication, and provides a plurality of single LEDs to indicate statuses such as power on, message waiting, set-top output disabled, etc. I/R receiver **54** receives and digitizes input from remote control **59**. I/R transmitter **56** controls a VCR **60** and sends updates to remote control **59**. Accessories bus **57** connects to external equipment such as keyboards, joysticks, mouses, I/R transmitters, etc. The 10-base-T interface can be used to connect to Ethernet interfaces in equipment such as routers, personal computers, or home entertainment equipment.

FIGS. **4** through **35** illustrate the operation of preferred embodiments of the application software of set-top terminal

6 of the present invention. Referring to FIG. 4, the operation of the channel selection function of one embodiment of the present invention is shown. From a first channel display 100, the channel selection function changes channels in response to pressing a channel up/down key 102 on set-top terminal 6 or its remote control 59. This causes a second channel display 106 to be displayed. In the preferred embodiment of the channel selection function, a program information banner 114 is displayed indicating the current channel's channel number 116, the current channel's call sign 118, current time 120, the current program's name 123, running time 125, and elapsed time 127. Banner 114 may also include information regarding the program following the program currently being transmitted. Banner 114 is preferably displayed for a fixed period of time.(e.g., 2 seconds) or until an information key 104 is depressed on set-top terminal 6 or its remote control 59. Pressing channel up/down key 102 again causes set-top terminal 6 to select the next channel in order. For example, as shown, pressing the up side of channel up/down key 102 causes the display to switch from channel 4 (KNBC) to channel 5 (HBO). Similar to the initial display of second display 106, the initial display of a third channel display 108 can include a program information banner 122.

Additionally, in the preferred embodiments of the present invention, pressing information key 104 from a first channel display 100 causes a program information banner 124 to be displayed on first channel display 100. Similar to program information banners 120 and 122, program information banner 124 can display the current channel's channel number, the current channel's call sign, the current time, the current program name, the program's running time, and the program's elapsed time. Like banner 114, banner 124 may also include information regarding the program following the program currently being transmitted. Pressing information key 104 again with program information banner 124 displayed preferably causes a more detailed program information banner 126 to be displayed on first channel display 100. Unlike banners 114, 122, and 124, more detailed program information banner 126 preferably does not display the running time and elapsed time but rather displays a brief description of the program's contents. As shown, program information banner 126 may omit the current program's name or, as in the preferred embodiments, may include the current program's name.

As an alternative to changing channels using channel up/down key 102 as shown in FIG. 4, channel selection can be accomplished by entering the number of a channel on a numeric keypad. Such a keypad is preferably on remote control 59 and can also be on set-top terminal 6. The channel number is entered on the numeric keypad one digit at a time from left to right, optionally preceded by zeros if the number of digits in the channel number is less than the number of digits required for the channel selection function. For example, in a set-top terminal with three-digit selection, a subscriber enters the channel number "125" by pressing the one-key, followed by the two-key, and then by the five-key. To enter the number "50" on a three-digit selection set-top terminal 6, the subscriber enters the number zero, then five, then zero, or simply enters a five followed by a zero. In the latter case, set-top terminal 6 automatically adds the leading zero to the channel number and selects the new channel accordingly.

In the preferred embodiments, the channel selection function of the present invention includes a plurality of channel cross-reference tables as shown in FIG. 5. These tables cross reference set-top terminal channels with a variety of television services, which can include various types of video and audio programming and online services. Transparent to subscribers, selection of a channel transfers control to a specific application program that, along with one or more appropriate parameters obtained from the cross-reference tables, activates (i.e., displays on the selected channel) the television service associated with that selected channel. The channel selection function advantageously enables set-top terminal 6 to process data from sources other than just traditional analog video broadcast sources. These other sources can include, for example, MPEG video, VBI, IP, and ROM.

Referring to FIG. 5, channel table 101 associates channels of set-top terminal 6 with a plurality of television services listed in service table 103. When a subscriber selects a channel, that channel is first identified in channel table 101 where a pointer associates the channel with a particular service in service table 103. For example, channel 5 is associated with service 4, channel 7 is associated with service 6, and channel 14 is associated with service 14.

Service table 103 preferably indicates the type of service provided. For example, as shown in column 111, services 1–5 are video services, service 6 is a split service (described below), services 12 and 13 are music services, and service 14 is an NVOD service. Optionally, a channel does not have to be associated with a television service, in which case it is associated with "null" service 0 (e.g., channels 8 and 9 are associated with service 0). Other service types, such as, for example, a home shopping service, a still image library service, an online database service, a World Wide Web browsing service, or an E-Mail service, can be added to service table 103 and are represented in service table 103 by "other" service 16.

Service table 103 preferably provides descriptive information for each television service listed. Represented by column 125, this information may include, for example, the service's logo, programming schedule, and program content, and can be used as a source for the program information banners described previously or the browse information banners and interactive program guide described in more detail further below.

Service table 103 further preferably provides parameter references as shown in column 123 for identifying sources of listed television services. The parameter references point to parameter tables, such as, for example, video parameter table 105, split parameter table 107, music parameter table 109, NVOD parameter table 127, VOD parameter table 129, and "other" parameter table 131.

Video parameter table 105 provides application parameters needed to activate video sources 1–9. The content of video sources 1–9 may include, for example, recently released movies, classic movies, science fiction programming, or weather information. Application software parameters are used by set-top terminal 6 (in particular, CPU 30) when executing application software, and may simply include the frequency of a particular source's signals or other more complex variables.

Split parameter table 107 allows a channel to be associated with two or more services, each during different time periods. These services can be of different types and from different sources. For example, if a subscriber selects channel 7, set-top terminal 6 determines from channel table 101 that channel 7 is associated with service 6. From service table 103, set-top terminal 6 determines that the source of service 6 is a split service governed by split parameter table 107. From split parameter table 107, set-top terminal 6 determines that channel 7 is associated with service 10

during time period one (time1) and service 11 during time period two (time2). Set-top terminal 6 then refers to video parameter table 105 to determine the sources and parameters for activating services 10 and 11. Thus, selecting channel 7 will cause set-top terminal 6 to activate source 8 during time period one and source 9 during time period two.

The other parameter tables function similarly to video parameter table 105. Music parameter table 109 identifies sources of music and provides the appropriate parameters for activating these sources. NVOD parameter table 127 provides application parameters for activating a Near-Video-On-Demand service and, similarly, VOD parameter table 129 provides application parameters for activating a Video-On-Demand service. Other Parameter Table 131 is representative of other television service sources and application parameters that can be provided by a cable system of the present invention.

In sum, the cross reference tables of the channel selection function enable set-top terminal 6 to execute software and activate a variety of television services. When a subscriber selects a channel, set-top terminal 6 identifies the type of service associated with the selected channel from channel table 101 and service table 103, and then executes the appropriate program (or special routine within the running program that allows channel selection) to tune in the frequency of the service's source by referring to the appropriate parameter table, descrambling the signal if necessary, and displaying the source's contents on the selected channel. Advantageously, set-top terminal 6 can respond to other types of services that require more interaction. For example, a request to view a channel incorporating a World Wide Web browser results in set-top terminal 6 executing either a resident copy of a Web browser or a downloaded copy from the headend, requesting log-in information from the subscriber, and establishing a browsing session with the headend. Thus the types of services that can be provided to subscribers are not limited by set-top terminal 6. Preferably, new types of services can be added to the cable system's offerings by downloading a new service type module to set-top terminal 6. The cross-reference tables (i.e., channel, service, and parameter tables) are accordingly updated and the new module can then be executed whenever a subscriber selects a channel corresponding to that service.

Furthermore, by configuring set-top terminal channel settings based on entries in service table 103 rather than on entries in channel table 101, changes in the cable channel lineup over which television services are transmitted to set-top terminal 6 do not invalidate a subscriber's set-top terminal channel settings. In other words, the subscriber's mapping of set-top terminal channels to television services is maintained even if the cable service provider reassigns the cable channels over which those services are transmitted. Preferably, when such a reassignment occurs, an updated channel-to-service mapping corresponding to the reassignment is downloaded to set-top terminal 6 to maintain the existing association of set-top terminal channels to television services. Thus, for example, once parents configure channel settings to block particular services deemed inappropriate for their children, a reassignment of cable channels over which those services are transmitted will not affect those services' blocked status. Similarly, other channel settings, such as a subscriber's favorite channel line-up, will also not be affected if such cable channel reassignments occur.

To prevent channel settings from becoming invalid during the lifetime of a set-top terminal, television services listed in service table 103 of a preferred embodiment of the present invention are typically not deleted or replaced. Instead, a new service is assigned to reserved space or space which is dynamically allocated within service table 103.

The manner in which requests for services are made by different applications within set-top terminal 6 are simplified in a preferred embodiment of the present invention by incorporating a uniform resource locator (URL), similar to that on the Internet, to uniformly identify services requested. Services are identified by a URL that incorporates information regarding the format, physical location, logical location, and identity of the service requested (e.g., format://physical/logical/identity). For example, if a service is requested that resides on a server at the headend, the URL identifies the format (e.g., the headend's format), the particular server at the headend, the directory on that server, and the file in that directory. Alternatively, if a service is requested that resides in set-top terminal 6, the URL identifies the format (e.g., code segment format), the physical location (i.e., set-top terminal 6), the particular block of memory, and the memory address of the requested service.

FIG. 6 illustrates the "Browse" mode of the present invention. The browse mode is entered by pressing the up, down, left, or right arrow keys whenever a program information banner or more detailed program information banner is being displayed. For example, from a television display 110 incorporating either a program information banner 124 or a more detailed program information banner 126, pressing up or down arrow keys 128 causes a browse information banner 132 to be displayed. Browse information banner 132 displays information for programs other than that currently being displayed on display 110. As shown, a program entitled "Comedy: D. Miller" is being displayed on display 110 (see program information banner 124). However, browse information banner 132 reflects information for a program entitled "CBS Sports." The subscriber can therefore determine what other programs are available for viewing while still observing the currently selected program. By repeatedly pressing up or down arrow keys 128, information regarding other concurrently transmitted television programs can also be displayed on browse information banner 132. Pressing information key 104 whenever a browse information banner 132 is displayed causes banner 132 to be replaced by a more detailed browse information banner 142 displaying a brief description of the browse program rather than the browse running time and elapsed time. As with the program information banner 126, browse information banner 142 may omit the browse program's name (as shown) or, as in the preferred embodiments, may include the browse program's name.

The browse mode of set-top terminal 6 can be exited by pressing channel up/down key 102, by pressing select key 136, by pressing information key 104 whenever more detailed browse information banner 142 is displayed, or by waiting a fixed period of time (e.g., 20 seconds) without pressing any remote control 59 or set-top terminal 6 key. More particularly, pressing channel up/down key 102 with a displayed browse information banner 132 causes the following: the banner is removed from the display, the channel tuner selects and displays the next channel following the previously displayed channel (in this case channel 4 follows the previously displayed channel 3 since the up side of channel up/down key 102 was pressed), and a program information banner 133 is displayed for the new channel as shown in channel display 106. Alternatively, pressing select key 136 with browse information banner 132 displayed causes set-top terminal 6 to tune in and display browse channel 138 and to briefly display a program information banner 140.

The browse information banner can also be used to display information for programs that were or will be transmitted. For example, as shown in FIG. **7**, browse information banner **152** can be used to display information for a program airing in twenty minutes from the current time. This can be done, for example, as follows: from a program information banner **124** displayed within a television display **110**, the browse mode of set-top terminal **6** is entered by pressing up arrow key **128**. With the browse mode entered, a browse information banner **148** displays information for a browse channel (i.e., channel **4**, KNBC) during a browse period which straddles the current time (i.e., 8:10 p.m.). By pressing right arrow key **128**, the browse period changes to the period for the next program on the browse channel. Alternatively, the subscriber can press left arrow key **128** to change the browse period to the previous program on the browse channel. In a similar fashion, by repeatedly pressing up, down, left, and right arrow keys **128**, the subscriber can view information for programs on other channels and at different times.

As described in connection with FIG. **6**, once the subscriber has viewed browse information banner **152**, more detailed information can be obtained or the subscriber can exit the browse mode of set-top terminal **6**. For example, by pressing information key **104** with the browse information banner **152** displayed, the subscriber causes browse information banner **152** to be replaced by a more detailed browse information banner **154**. Banner **154** may replace the program name, running time, and elapsed time of banner **152** with a brief description of the browse program's contents. Alternatively, the browse mode may be exited by pressing channel up/down key **102** to view a new channel display **158** or by not pressing any keys on remote control **59** or terminal **6** for a fixed period of time (e.g., 20 seconds).

Although the embodiment of the browse banner shown in FIGS. **6** and **7** is activated from the program information banner by pressing the up or down arrow keys, the browse banner of the present invention can also be activated by pressing the left or right arrow keys from the program information banner.

FIG. **8** provides a more detailed illustration of an embodiment of the browse information banner of the present invention. As shown, browse information banner **160** can display the browse channel's channel number **160**, call sign **162**, logo **164**, a favorite channel icon **166**, a blocked channel icon **168**, current time **170**, the browse program's name **172**, running time **174**, elapsed time **176**, and icons to indicate whether the browse program is closed-captioned **178**, has a second audio program **180**, is in stereo **182**, and is designated to be recorded **184**.

As shown in FIG. **9**, a channel settings menu **190** allows the subscriber of set-top terminal **6** to change the favorite, blocked, and record status for each channel. The subscriber enables channel settings menu **190** by pressing a settings key **188** on set-top terminal **6** or its remote control **59** from any television display **186**. As illustrated, channel settings menu **190** may be incorporated into the previously viewed television display **186** while leaving the television audio unaffected. Within channel settings menu **190**, settings may be provided which allow the subscriber to add the current channel (i.e., KCBS) to the favorite channel list (setting **200**), block the current channel (setting **202**), and record the current channel (setting **204**). To select any of settings **200**, **202**, or **204**, the subscriber highlights one of the settings by positioning the setting within cursors **198** and **216** by pressing up or down arrow keys **128**. In the preferred embodiments of the present invention, cursors **198** and **216** remain in a fixed vertical position within menu **190** as the subscriber presses up and down arrow keys **128** and the list of settings scrolls such that the settings list comprising settings **200**, **202**, and **204** moves in the opposite direction of the key pressed. That is, when the subscriber presses up arrow key **128**, the list moves down and the cursor remains fixed, thereby giving the net effect of the cursor moving up within the list. Set-top terminal **6** indicates that the subscriber may press up and down arrow keys **128** to highlight different settings using cursors **198** and **216** by providing up and down arrow indicators **194** and **196**. With cursors **198** and **216** on the desired setting, the subscriber may then enable or disable the highlighted setting by pressing left and right arrow keys **128**. Similarly to up and down arrow indicators **194** and **196**, menu **190** provides left and right arrow indicators **206** and **208** to indicate that the subscriber may press left and right arrow keys **128** to enable or disable the highlighted setting. Setting indicators **210**, **212**, and **214** will shift position to beneath either the "YES" column **218** or "NO" column **220** to indicate to the subscriber whether each function is enabled or disabled, respectively.

A general settings menu **224**, as shown in FIG. **10**, is also provided in a preferred embodiment of the present invention. Menu **224** enables a subscriber to make further settings adjustments to set-top terminal **6**. The subscriber enters general settings menu **224** by pressing settings key **188** from channel setting menu **222**. As with the channel settings menu **222**, general settings menu **224** may be incorporated into the previously displayed television display **250** without affecting the television audio. Within general settings menu **224**, the subscriber may control settings such as blocked channels **228**, favorite channels **230**, VCR timers **232**, IPPV purchases **234**, sleep timers **236**, and wake timers **238**. Other settings available in general settings menu **224**, but not illustrated, can include, for example, reminder timers, view all timers, block times, setup blocking PIN, setup purchase PIN, set power-on channel, enable second audio program (SAP), set audio output level, set AC outlet function, set VCR type, set clock options, control VCR on/off, and enable watch and record. Similarly to channel settings menu **190** (FIG. **9**), a subscriber selects the desired setting by positioning the desired setting **228**, **230**, **232**, **234**, **236**, or **238** within a cursor **226** using up and down arrow keys **128**, as is indicated by up and down arrow indicators **240** and **242**. As with channel settings menu **190**, in the preferred embodiments of the present invention, cursor **226** remains in fixed vertical position within general settings menu **224** and the list of settings scroll in a direction opposite to the direction of the up and down arrow keys depressed.

Once the desired setting has been highlighted by cursor **226**, the subscriber may then view or modify contents of the setting by pressing right arrow key **128** (as is indicated by right arrow indicator **246**) or select key **136** to move cursor **226** to right half **248** of general settings menu **224**. In cases where a setting has not been previously set or the contents of the setting have been erased, an indication such as "(New . . .)" will be displayed in right half **248** of menu **224** to indicate to the subscriber that the setting is empty. When the subscriber has completed using general settings menu **224**, the subscriber may exit the menu by pressing settings key **188** to return to previous television display **250**. Alternatively to exiting the general settings menu **224**, the subscriber may also select another general setting by returning to the left half of menu **224** by pressing left arrow key **128**, as indicated by left arrow indicator **244**.

FIGS. **11** through **15** illustrate the VCR timers, IPPV purchases, all timers, and favorite channel settings of the

general settings menu. Referring to FIG. **11**, one embodiment of the VCR timers setting is shown. Selecting the VCR timers setting by pressing right arrow key **128** or select key **136** with VCR timers setting **256** highlighted in general settings menu **254** causes cursor **255** to be removed from the display and a new cursor **257** to be displayed in the left-most column of right half **248** of the general settings menu as shown in menu **258**. In cases in which the VCR timers setting is selected when contents for the setting do not exist, set-top terminal **6** will determine default contents for the setting. The contents may be either the current program being viewed prior to entering the general settings menu, or may be the next program to be aired if within a fixed period of time (e.g., 10 minutes) of the start time of the next program. Pressing either up or down arrow keys **128** causes each parameter to cycle to the next higher or lower value for that parameter. As shown in menu **260**, pressing up arrow key **128** causes the date to change from "Mo **23**" to "Tu **24**." Pressing right arrow key **128** or select key **136** causes cursor **257** to be removed from the display and a new cursor (e.g., cursor **259**) to be displayed in the next, rightward, parameter as shown in menu **262**. Alternatively, pressing left arrow key **128** causes cursor **257** to be removed from the display and a new cursor to be displayed in the previous parameter. By using arrow keys **128** in this fashion, the subscriber is able to select the date, channel, start time, and stop time for the VCR timers setting.

Once the subscriber has modified the contents of the VCR timer setting, the subscriber may accept or cancel the modifications as indicated by "A" and "C" indicators **261** and **263**. To accept the modified setting, the subscriber presses the "A" application definable key **252**. If the subscriber accepts the settings, a cursor will be displayed in list of settings **249** and the modified setting will be displayed as shown in menu **264**. To cancel the modified setting, the subscriber presses "C" application definable key **252**. Alternatively, if left arrow key **128** is pressed when a cursor is displayed in the left-most column in right half **248** of the general settings menu (as shown in menu **258**), any changes to the setting will be canceled. Once canceled, a cursor will be displayed in list of settings **249** and the prior contents of the setting will be displayed.

FIG. **12** illustrates the conflict checking feature of the present invention. Upon pressing select key **136**, settings key **188**, or channel up/down key **102** after modifying a timer setting's contents from within general settings menu **268**, set-top terminal **6** verifies that there are no conflicts created by the modified setting. Conflicts can arise, for example, when there are overlapping timers, unusual settings (such as VCR record timers which exceed typical tape length), record timers for unpurchased Impulse Pay-Per-View (IPPV) events, attempts to set up more than a limited number of VCR timers (e.g., eight), and attempts to purchase more than a limited number of IPPV events (e.g., eight). For example, upon pressing select key **136** from general settings menu **268** when attempting to record an IPPV event, set-top terminal **6** displays an interactive warning window **270** alerting the subscriber that the IPPV event sought to be recorded has not been purchased. Interactive warning window **270** then allows the subscriber to press "B" or "C" application definable keys **252** to either buy the IPPV event or cancel the warning. Pressing select key **136** from general settings menu **268** for non-IPPV events causes another interactive warning window **272** to be displayed when there are conflicting timers. For example, interactive warning window **272** is displayed when there is an attempt to record two different programs at overlapping times. As illustrated, the subscriber has the choice of selecting one of "A," "B," and "C" application definable keys **252** in response to this warning in the preferred embodiment. Pressing "A" key **252** causes set-top terminal **6** to keep both settings and apply logic to resolve the conflict as shown in menu **274** ("VCR Timer 1" referring to the first setting and "VCR Timer 2" referring to the second). This can be accomplished, for example, in cases where two recording timers partially overlap by recording up until the start time of the second program and dropping the end of the first program. Pressing "B" key **252** in response to interactive warning window **272** causes the conflict to be resolved by a new setting that overwrites the old setting as shown in menu **276**. Pressing "C" key **252** in response to interactive warning window **272** causes the old setting to be retained in general settings menu **278** and cursor **226** to remain displayed on right side **248** of the general settings menu to indicate to the subscriber that the most recent setting has not been accepted.

When the subscriber exits general settings menu **268** by pressing settings key **188** or channel up/down key **102** while leaving behind a conflicting setting, a non-interactive warning window **280** is displayed for a brief period of time (e.g., five seconds) to inform the subscriber of the conflict. To resolve the conflict, the subscriber must press settings key **188** to reenter the general settings menu. Upon reentering the general settings menu, the subscriber is prompted with interactive warning window **272** so the conflict can be resolved using the procedure previously described.

FIG. **13** illustrates the Impulse Pay-Per-View (IPPV) purchases setting of the general settings menu. As shown in general settings menu **284**, whenever IPPV Purchases setting **286** is highlighted, a summary indicator **288** is displayed in right half **248** of the general settings menu. Indicator **288** indicates the number of past and pending IPPV purchases. Pressing right arrow key **128** or select key **136** causes summary indicator **288** to be replaced by list **290** of past and pending purchases as shown in general settings menu **292**. In the preferred embodiments of the present invention, a pending purchase can be removed from list **290** by pressing stop key **282** with a particular purchase highlighted. For example, with "$^{9}/_{18}$ The Fugitive" highlighted in menu **292**, pressing stop key **282** causes "$^{9}/_{18}$ The Fugitive" to be removed from subsequent list **296** in subsequent menu **294**. As with highlighting different settings **249** in the general settings menu, the IPPV purchases are highlighted by positioning the IPPV purchase within cursor **255** using up and down arrow keys **128**. Like the cursor in the general settings menu, cursor **255** is preferably fixed in the vertical position.

When done reviewing list **290** of past and pending IPPV purchases, the subscriber may press the "A" application definable key **252** to exit. In response, the present invention removes the list from right side **248** of the general settings menu, replaces the list with an updated summary indicator **300**, and highlights IPPV Purchases setting **286**. In an alternative embodiment of the present invention (not shown), the subscriber may also press "C" application definable key **252** to cancel any IPPV cancellations that were made by highlighting a pending IPPV event and pressing stop key **282**.

FIG. **14** illustrates an embodiment of the all timers setting of the general settings menu. As shown, selecting all timers setting **323** within general settings menu **322** causes list **325** of type **324**, day **326**, date **330**, time **332**, channel number **334**, and channel call sign **336** for each active timer in set-top terminal **6** to be displayed. As with IPPV purchases (see the description accompanying FIG. **13**), pressing stop

key **282** with any timer highlighted causes that timer to be canceled and accordingly removed from all timers list **325**. As indicated by up and down arrow indicators **327** and **329**, up and down arrow keys **128** are used to highlight timers within list **325** by positioning a timer within cursor **255**. As with the other settings, cursor **255** is preferably fixed in the vertical position. Once the subscriber has completed reviewing and modifying all timers list **325**, the subscriber may accept the changes by pressing "A" application definable key **252** as indicated by prompt **328**. In an alternative embodiment of the present invention (not shown) the subscriber may also press "C" application definable key **252** to cancel any timer cancellations made by highlighting a timer and pressing stop key **282**.

The favorite channels setting of the general settings menu is shown in FIG. **15**. By selecting favorite channels setting **304** of general settings list **249** the subscriber causes listing **306** of favorite channels to be displayed on right side **248** of general settings menu **302**. Pressing "C" application definable key **252** causes list **306** to be cleared as represented by list **306** in menu **308**. Pressing right arrow key **128** or select key **136**, however, brings up an available channel list **310** as shown in menu **312**. List **310** shows all of the available channels along with check marks **311** next to the channels which are included in favorite channel listing **306**. Pressing right arrow key **128** or select key **136** while a channel within available channel list **310** is highlighted causes the highlighted channel to be toggled to and from favorite channel list **306** as shown in menu **314**. That is, if the channel is included in list **306**, and therefore checked in list **310**, pressing right arrow key **128** or select key **136** causes the channel to be removed from favorite channel list **306** and unchecked in list **310**. On the other hand, with a channel not listed in favorite channel list **306**, and therefore not checked in available channel list **310**, pressing right arrow key **128** or select key **136** causes the channel to be added to favorite channel list **306** and checked in available channel list **310**. As with other settings within the general settings menu, channels within list of available channels **310** are highlighted by positioning the channel within cursor **255** by pressing up and down arrow keys **128**. General settings menu **316** illustrates a preferred embodiment of the present invention in which cursor **255** remains in fixed vertical position within list **310**. As shown, available channel list **310** was scrolled from that shown in menu **312** to highlight "**28** DISC." Once highlighted, right arrow key **128** or select key **136** was pressed to add "**28** DISC" to favorite channel list **306**.

When the subscriber has finished viewing and editing favorite channel list **306**, the subscriber may exit the favorite channels setting by pressing "Al" or "C" application definable keys **252**. Pressing "A" key **252** causes the additions and deletions to be accepted by set-top terminal **6** as shown in general settings menu **318**. Pressing "C" key **252**, however, causes all changes to be discarded and favorite channel list **306** to remain as it was prior to modification as illustrated in general settings menu **320**.

FIG. **16** illustrates the time mode of interactive program guide (IPG) **338** of the preferred embodiments of the present invention. As shown, guide **338** includes program viewing window **340**, current time and channel indicator **342**, highlighted channel banner **344**, highlighted program summary **346**, guide date and time bar **348**, channel list **350**, program grid **366**, and key indicators **352**, **354**, **356**, **358**, **360**, **362**, and **364**. As shown, region **339** around indicator **360** is highlighted as compared with regions **341** and **343** around indicators **362** and **364**, respectively, to indicate that the interactive program guide is in the time mode rather than alternative theme or title modes. Program viewing window **340** displays a reduced size display of the normal television display so that the program being viewed prior to entering the program guide may continue to be viewed while in the guide. Incorporated into program viewing window **340** is a current time and channel indicator **342**. Indicator **342** may be transparent or opaque, and displays the time and channel number currently being displayed. Highlighted channel banner **344** may indicate logo **368**, call sign **370**, and number **372** for the channel highlighted in channel list **350** by channel shadow **392**. Highlighted program summary **346** may list program name **374**, running time **376**, brief description **378**, and icons **380** indicating applicable characteristics of the program such as closed captioning, second audio program (SAP), and stereo for the program highlighted in program grid **366** by program cursor **394**. Guide date and time bar **348** lists in a preferably horizontal arrangement, from left to right, day **382**, date **384**, and times **386** of programs listed in program grid **366**. Times **386** are typically incremented in half hour steps, and span one and a half hours, although other time increments and spans can be used. Channel list **350** is positioned beneath day **382** and date **384** indicators of guide date and time bar **348**, and lists call signs **388** and channel numbers **390** for each of the channels available to the subscriber. As shown, only a portion of channel list **350** is usually displayed as indicated by up and down arrow indicators **352** and **354**.

Program grid **366** includes a plurality of rows, each including at least one program cell **396**. The number of rows in grid **366** matches the number of displayed channels in channel list **350**, and each row in grid **366** is horizontally aligned with the displayed channels in channel list **350** so that the displayed channels act as labels for each row. The size of each cell **396** in grid **366** is a function of the running time of the program identified in that cell. For example, the cell entitled "Encounters" in grid **366** is one half hour long to indicate that the program "Encounters" is one half hour long. Similarly, the cell entitled "Money Line" in grid **366** is one hour long to indicate that the program "Money Line" is one hour long. The start time of each program identified in a respective cell can be determined by referring to the time indicated in date and time bar **348** directly above the leftmost end of each cell. For example, the program entitled "Money Line" begins at 4:30 p.m. as indicated by the time indicator "4:30 p.m." positioned directly above the leftmost end of the cell identifying "Money Line."

The subscriber of interactive program guide **338** navigates the program listings of grid **366** to highlight a desired program cell **396** with cursor **394** by pressing up, down, left, and right arrow keys (not shown) as indicated by up, down, left, and right arrow indicators **352**, **354**, **356**, and **358**. In the preferred embodiments, cursor **394** is always shadowed in channel list **350** by channel shadow **392** and in date and time bar **348** by time shadow **393**. In these embodiments, channel shadow **392** always remains horizontally aligned with cursor **394** to indicate the channel on which the program highlighted by cursor **394** can be found. Similarly, in these embodiments, time shadow **393** always remains vertically aligned with cursor **394** to show the beginning of the time frame highlighted by cursor **394**. For example, "KCBS **2**" in channel list **350** and "4:00 p.m." in date and time bar **348** are shadowed by channel shadow **392** and time shadow **393**, respectively, to indicate that "CBS Sports . . . " is on channel "KCBS **2**" at "4:00 p.m."

In the preferred embodiment of the present, invention, cursor **394** does not move within grid **366** of the interactive

program guide. Program cells **396** of grid **366**, call signs **388** and channel numbers **390** of channel list **350**, and times **386** of date and time bar **348** scroll instead. For example, as a subscriber presses up and down keys **128** (on remote control **59** or keypad **53** on set-top terminal **6**), call signs **388** and channel numbers **390** in channel list **350** and program cells **396** in grid **366** scroll down and up, respectively. As the subscriber presses left and right arrow keys **128**, times **386** in date and time bar **348** and program cells **396** in grid **366** scroll right and left, respectively. In the vertical directions, call signs **388**, channel numbers **390**, and cells **396** scroll one row for each depression of up or down arrow key **128**. In the horizontal direction, times **386** and cells **396** scroll one time increment (e.g., one half hour as illustrated) for each depression of the left or right arrow key **128**. Alternatively, times **386** and cells **396** can horizontally scroll to the next program cell **396** immediately following the currently highlighted program cell **396** when the subscriber presses right arrow key **128**, and scroll to the previous program cell **396** immediately preceding the currently highlighted program cell **396** when the subscriber presses left arrow key **128**. After the cells have scrolled up or down, or left or right, the stationary cursor **394** expands or contracts to highlight (preferably entirely) the leftmost program cell, and only the leftmost program cell, that has moved under the cursor's stationary position. Thus, the stationary cursor reacts in the same manner (to highlight the underlying cell) irrespective of the direction of movement of the underlying program grid **366**.

As shown in FIG. **16**, in a preferred embodiment of the present invention, channel list **350** rolls over when either the beginning or end of the list is reached. For example, as a subscriber scrolls list **350** upward, thereby giving the appearance of the channel shadow moving downward with respect to the list, the subscriber eventually reaches the end of the list of available channels. Rather than simply preventing the subscriber from scrolling list **350** any further when at the end of the list, set-top terminal **6** displays the beginning of the list following the end of the list and allows the channel shadow to move to the top of the list. Channel list **350** thus appears to be a circular list of channel numbers. Similarly, when the subscriber scrolls list **350** downward, thereby giving the appearance of the channel shadow moving upward with respect to the list, the bottom of list **350** will appear as the subscriber scrolls past the beginning of list **350**. This feature of list **350** may also be applied to other lists within the present invention, including lists of settings, IPG guide data (in grid format), etc. Alternatively, the present invention can incorporate lists that do not roll over. In those cases, the subscriber cannot continue scrolling the channel list in the same direction once the top or bottom of the channel list has been reached.

As described in connection with FIG. **5**, the present invention makes special provisions for channels which are split in time between two or more sources. As shown in FIG. **17**, channel "**147**" within interactive program guide display **361** is split between "BRAV" **363** and "LIFE" **365**. As illustrated, channel "**147**" switches from "BRAV" to "LIFE" at 5:00 p.m. Similarly, other splitting arrangements can be configured. For example, channel "**147**" (or any other channel number) can be used for three different daily sources, such as "BRAV" from 12:00 a.m. to 7:59 a.m., "LIFE" from 8:00 a.m. to 3:59 p.m., and "QVC" from 4:00 p.m. to 11:59 p.m. In such an arrangement, channel **147** can be presented in program grid **366** in at least two manners. First, each of the sources, "LIFE," "BRAV," and "QVC," can be assigned a row in grid **366** at all times during the day regardless of whether the source is "ON AIR" during the time window displayed in the guide. Second, only those sources that are at least partially "ON AIR" during the time window displayed in the guide are allocated a line in grid **366**. In this second approach, for example, displaying programs with times ranging from 3:00 p.m. to 4:30 p.m. shows a split at 4:00 p.m. with only two lines of the program guide allocated to channel **147**.

FIG. **18** further illustrates the navigation features of the interactive program guide of the preferred embodiments of the present invention. Pressing guide key **398** from any television display **396** causes set-top terminal **6** to enter the time mode of interactive program guide **400**. As shown, pressing right arrow key **128** causes the contents of cell **404** to scroll to cell **406** as illustrated in IPG **402**. Similarly, the contents of all other cells scroll from their current position to the cell immediately to their left. Likewise, pressing left arrow key **128** causes the contents of the cells to scroll to the right. Thus the cell contents scroll in time, causing the cursor to highlight either the contents of an earlier or later cell under the action of left and right arrow keys **128**, respectively. Similarly, pressing either up or down arrow keys **128** causes the cell contents to scroll vertically either down (with the contents of cell **407** moving to the position of cell **406**) or up (with the contents of cell **409** moving to the position of cell **406**), respectively, as shown in IPG **408**. As the cell contents of grid **366** scroll up and down, the contents of channel list **350** also simultaneously scroll in the same direction.

After scrolling the contents of grid **366** to highlight a program other than the one currently being displayed, pressing select key **136** causes the interactive program guide to be removed from the display and the channel selection function to select the new program as illustrated by display **410**. As shown, a program information banner **412** may be incorporated into display **410** for a fixed period of time (e.g., two seconds) to indicate to the subscriber that the selected program is being displayed. In cases where the subscriber does not wish to switch to a new program, pressing guide key **398** with the interactive program guide displayed causes the display to revert back to original television display **396**.

FIG. **19** illustrates switching between different modes of the interactive program guide. From time mode display **414** of the guide, pressing "B" application definable key **252** causes theme mode display **416** of the guide to be presented. As illustrated, region **341** is highlighted to indicate the theme mode. Pressing "C" application definable key **252** from time mode display **414** causes title mode display **418** of the guide to be displayed. Similar to the theme mode, region **343** is highlighted to indicate the title mode. From either the theme mode or title mode, pressing "A" application definable key **252** causes the display to switch to time mode display **414**. From the theme mode, pressing "C" application definable key **252** causes title mode display **418** to be displayed. From title mode display **418**, pressing "B" application definable key **252** causes theme mode display **416** to be displayed. Accordingly, pressing "A" key **252** from any IPG display causes time mode display **414** to be displayed, pressing "B" key **252** from any IPG display causes theme mode display **416** to be displayed, and pressing "C" key **252** from any IPG display causes title mode display **418** to be displayed.

The theme mode display of the interactive lo program guide is further illustrated in FIG. **20**. As shown, date and time bar **348**, channel list **350**, and program grid **366** of the title mode display (FIG. **16**) are replaced by theme and programs bar **422**, theme list **424**, and program list **432** in

theme mode display **420**. Similarly to channel listing **350**, all available themes will not be displayed simultaneously when the length of themes listing **424** is greater than the available space in theme mode display **420**. Up and down arrow indicators **426** and **428** are provided to indicate to the subscriber that list **424** may be scrolled by pressing up or down arrow keys (not shown). Using up and down arrow keys, the subscriber can scroll list **424** to highlight a desired theme with cursor **430**. A right arrow indicator **434** is also provided to indicate to the subscriber that a highlighted theme must be selected by pressing right arrow key (not shown) or select key (not shown) to scroll though program list **432**. As shown, when the subscriber enters theme mode display **420**, the default theme and highlighted program may correspond to the program being viewed in program viewing window **340** or, alternatively, a highlighted program in a prior mode display of the interactive program guide. For example, entering the interactive program guide while watching "CBS Sports Special" and then selecting the theme mode will cause the theme "Sports" to be highlighted with "CBS Sports Special" centered in program list **432** next to right arrow indicator **434**.

Once the subscriber has highlighted and selected a theme from theme list **424**, set-top terminal **6** replaces theme list **424** with a selected theme indicator **436** as illustrated in FIG. **21**. Up and down arrow indicators **437** and **439** are also provided to indicate that the subscriber may scroll through and highlight with cursor **440** a program within program list **432** by pressing up and down arrow keys **128**. As with other lists in the present invention, cursor **440** is preferably stationary within the IPG display and list **432** scrolls to make the cursor appear to move with respect to list **432**.

In some embodiments of the present invention, by scrolling through program list **432** the subscriber can see not only those programs within the selected theme, but also programs in other themes. This is facilitated by program list **432** comprising all programs for which data is available and by program list **432** being sorted primarily by program theme. In addition to being primarily sorted by theme, programs in program list **432** may also be secondarily sorted by time and title (as shown) or by any other set of program characteristics. When a subscriber selects a particular theme, set-top terminal **6** displays that portion of program list **432** in which the programs of the selected theme are positioned. The subscriber may then scroll through not only that portion of the list containing the programs of the selected theme but also programs in other theme areas.

By highlighting a desired program in program list **432**, information for that program may be displayed to the subscriber. As shown in FIG. **21**, information for the program highlighted in program list **432** is displayed in channel banner **344** and program summary **346**. More particularly, channel banner **344** may indicate the channel number, call sign, and logo for the channel showing the highlighted program, and program summary **346** indicates the program title, running time, description, and characteristics for the highlighted program. As also shown, redundant information such as the date of the programs listed in program list **432** may be incorporated into theme and programs bar **422** when appropriate to save space in theme mode display **420**. Stars **442** (or any other symbol) may be indicated for those programs in list **432** currently available for viewing. Likewise, other indicators can be displayed to indicate other program characteristics such as favorite channel, blocked channel, etc.

Once a subscriber has completed viewing the program list **432**, the subscriber may select a program for viewing or alternatively return to the theme list to select another theme. The subscriber may select a program for viewing by highlighting a program with cursor **440** and then pressing the select key (not shown). Set-top terminal **6** then switches to the corresponding channel when the program is a past or current program, or sets a reminder timer when the program is on at some future time. Alternatively, the subscriber may return to theme list **424** to select another theme by pressing the left arrow key (not shown) as indicated by left arrow indicator **438**.

The title mode of the interactive program guide of the present invention is illustrated in FIG. **22**. Like the theme mode, the title mode replaces date and time bar **348**, channel list **350**, and program grid **366** of the time mode display (FIG. **16**) with alphabet and program bar **446**, alphabet list **448**, and program list **450** as shown in title mode display **444**. Alphabet list **448** displays the letters of the alphabet from A through Z and allows the subscriber to highlight a desired letter using cursor **452**. Similarly to the theme mode display, a default letter and program name are displayed upon entering the title mode display of the interactive program guide. The default letter and program name selected may be based upon the program currently displayed in program viewing window **340** or, alternatively, a program highlighted in a previous mode of the interactive program guide. For example, if "CBS Sports Special" is being displayed in program viewing window **340**, the default letter and program are accordingly "C" and "CBS Sports Special," respectively.

By using up and down arrow keys (not shown), as indicated by up and down arrow key indicators **454** and **456**, a subscriber can highlight a desired letter with cursor **452** by scrolling alphabet list **448**. As with other lists in the present invention, cursor **452** is preferably stationary within the IPG display and list **448** scrolls to make the cursor appear to move with respect to list **448**. Once a desired letter has been highlighted, the subscriber may select that letter and enter program list **450** by pressing right arrow key (not shown) or select key (not shown), as indicated by the right arrow indicator **458**.

As shown in FIG. **23**, once the subscriber has selected a letter from alphabet list **448** (FIG. **22**), a selected letter indicator **460** replaces alphabet list **448** to indicate that a letter has been selected, and a cursor **462** appears in program list **450**. This cursor is used to scroll through and highlight a program in program list **450**. Up and down arrow indicators **464** and **466** are provided in display **444** to indicate to the subscriber that program list **450** is scrolled by pressing up and down arrow keys **128**. As with other lists in the present invention, cursor **462** is preferably stationary within the IPG display and list **450** scrolls to make the cursor appear to move with respect to list **450**.

In some embodiments of the present invention, a subscriber can see not only those programs beginning with the letter selected from alphabet list **448** by scrolling through program list **450**, but also those programs beginning with other letters. This is facilitated by including in list **450** all programs for which data is available and sorting the list by program title. When displaying the list to a subscriber after the subscriber has selected a letter from list **448**, set-top terminal **6** centers the displayed portion of list **450** on the portion of the list with program titles that begin with the selected letter.

Once a program has been highlighted using cursor **462**, channel banner **344** and program summary **346** each display information for the highlighted program. More particularly,

channel banner **344** indicates the channel number, call sign, and logo for the channel showing the highlighted program, and program summary **346** indicates the program title, running time, description, and characteristics for the highlighted program. As with the theme mode display, stars **468** may be displayed adjacent to some programs to indicate that those programs are currently available for viewing. Similarly, other icons can be displayed to indicate other characteristics of the programs in program list **450** such as favorite channel, blocked channel, etc.

Once a subscriber has completed viewing program list **450**, the subscriber may select another letter from alphabet list **448** by pressing the left arrow key (not shown) as indicated by left arrow indicator **468**. Alternatively, by pressing the select key (not shown) when any program is highlighted by cursor **462**, the program guide switches to the corresponding channel if the program is a past or current program, or sets a reminder timer if the program is on at some future time.

FIG. **24** illustrates the One-Touch Recording (OTR) feature of the present invention. From an interactive program guide display **470**, pressing record key **472** with a program **474** highlighted causes a VCR timer to be set up for the highlighted program **474** and a to-be-recorded indicator **476** to appear in program summary **346**, as illustrated in display **478**. To fine-tune the settings of the VCR timer set up by the OTR feature, the subscriber may enter the general settings menu by pressing settings key **188**. As shown in general settings menu **480**, by highlighting and selecting VCR timers setting **482**, the subscriber can modify the recording settings **484** for highlighted program **474**.

As discussed in connection with the general settings menu (see FIG. **12**), conflict detection and resolution is also incorporated into the OTR feature of the present invention. Conflict detection and resolution detects and alerts the set-top terminal subscriber of possible timer conflicts at the time the timers are set up to prevent timers from being erroneously set or over-written. For example, the OTR feature will alert the subscriber if an attempt is made to simultaneously record two or more programs as illustrated in FIG. **24**. As shown, if after having set up a program to be recorded using One-Touch Recording (display **478**), the subscriber attempts to record another program which is being shown at the same time by first highlighting (display **486**) and then pressing record key **472**, an attention banner **488** will be displayed (display **490**) warning the subscriber of the conflict and enabling the conflict to be resolved.

The One-Touch Recording feature of the present invention also automatically warns the subscriber if an attempt is made to record an Impulse Pay-Per-View program without having previously made arrangements to purchase the program. As shown in FIG. **25**, pressing record key **472** with an Impulse Pay-Per-View program **494** highlighted causes a buy option window **496** to be displayed. In addition to providing the subscriber with a summary of program information **498**, "B" and "C" application definable keys **252** are monitored to determine if the subscriber would like to purchase the program or cancel the OTR event. If the subscriber presses "B" application definable key **252** with buy option window **496** displayed, a buy confirmation window **500** is provided to confirm the subscriber's purchase request. If in response to the buy confirmation window **500** the subscriber presses "C" application definable key **252**, the display will revert to buy option window **496**. If the subscriber presses "B" application definable key **252** in response to buy confirmation window **500**, set-top terminal **6** will prompt the subscriber for a purchase pin through a purchase PIN entry window **502**. If the PIN entered by the subscriber matches the PIN's predefined value, the display will switch back to interactive program guide display **504** and note the future recording by providing a record icon **506** when the program to be recorded is a future event, or will immediately display the Impulse Pay-Per-View event, as illustrated by display **508**, when the event is currently being shown.

FIG. **26** illustrates the reminder timer function of the present invention. With a program **510** highlighted within an interactive program guide display **512**, pressing select key **136** causes one of three things to occur. First, if the time between the current time and the start time of the program selected exceeds a threshold amount and the program selected is not on an Impulse Pay-Per-View channel, a reminder timer icon **516** is displayed in program summary **346** to indicate that set-top terminal **6** has set a reminder timer to remind the subscriber to watch the selected program as illustrated by display **514**. Second, set-top terminal **6** will display a buy option window **496** when the subscriber has selected a program on an Impulse Pay-Per-View channel. The interaction with this window matches that for the recording of Impulse Pay-Per-View programs as described in connection with FIG. **25**. Third, if the current time is within a threshold amount of time before the starting time of the selected program, set-top terminal **6** will tune to the channel on which the selected program is to be aired as illustrated by display **518**.

In addition to the information normally available in the program summary of the interactive program guide of the present invention, additional information may also be requested for a highlighted program by the subscriber pressing the information key on the set-top terminal or its remote control. FIG. **27** illustrates this process in a preferred embodiment of the present invention. After highlighting a program **523** within an interactive program guide display **522**, the subscriber may request more information for the highlighted program by pressing information key **520** if the information provided in program summary **346** is inadequate. Set-top terminal **6** may then incorporate a loading data window **524** into display **522** while retrieving the requested information. Once the information has been retrieved, loading data window **524** is replaced by a full description display window **530**. Full description display window **530** may include such information as a description of the program, the program's rating, the program's reviews, a list of the actors and actresses staring in the movie, etc. Once the subscriber has completed viewing full description display window **530**, pressing "C" application definable key **252** will cause full description display **530** to be removed and a fresh interactive program guide display **522** to be displayed.

The information displayed in the interactive program guide of the present invention may be sent to set-top terminal **6** from headend **2** in at least three ways. First, the information may be periodically transmitted to set-top terminals **6**, whereby the terminals store the information in their internal memory for use when necessary. Second, the information may be continuously transmitted to set-top terminals **6**, whereby the terminals need not store the information in their internal memory, but rather accept the information required for display and discard all of the rest as the information is received. Third, the information may be requested when needed by a set-top terminal **6** over the return data channel of the present invention, after which headend **2** transmits the requested information back to the set-top terminal. Additionally, combinations of these

approaches can also be implemented. For example, a week's worth of data can be regularly transmitted by the headend and stored in the set-top terminal's internal memory for display on demand by the subscriber. Other data, however, can be specifically requested by the set-top terminal when the subscriber wishes to view program information not regularly stored in the set-top terminal. Alternatively, rather than requesting the not-regularly-stored information, the terminal can wait for the data to be transmitted in an approach similar to the second approach above. As another example, the program summary data can be received and stored in the terminal's internal memory on a regular basis, with any full description information being requested from the headend by the set-top terminal as required.

FIG. **28** illustrates a process for purchasing an Impulse Pay-Per-View (IPPV) event within the present invention. Selecting an IPPV channel from either an interactive program guide display **540** or a television display **542** causes an event barker **544** to be displayed. This barker informs the subscriber of a currently showing or upcoming IPPV event. Event barker **544** provides a summary indicator **546** and buy indicator **548** to instruct the subscriber to press "A" application definable key **252** to view a summary of purchased IPPV events **550** or press "B" application definable key **252** to purchase the IPPV event. Upon selecting to purchase the IPPV event, a buy confirmation window **552** is displayed instructing the subscriber to press "B" application definable key **252** again or press "C" application definable key **252** to go back to event barker **544**. If the subscriber confirms the purchase of the IPPV event by pressing "B" application definable key **252** at buy confirmation window **552**, a PIN entry screen **554** will prompt the subscriber to enter a predefined purchase PIN. If the subscriber correctly enters the predefined purchase PIN and the IPPV event has already started, the set-top terminal will immediately tune to and display the IPPV event as is illustrated in display **560**. As is also shown, a program information banner **562** may be displayed momentarily to indicate to the subscriber that the program has been tuned and inform the subscriber of the program's elapsed time. If the subscriber has correctly entered the predefined purchase PIN and the event has not yet started or is a Near-Video-On-Demand (NVOD) or Pay-Per-Day (PPD) event, a countdown barker **556** will be displayed informing the subscriber of the time remaining until the beginning of the next showing of the program. At the time the program begins, the set-top terminal will automatically tune to and display the IPPV event. As illustrated by barker **558**, the set-top terminal may give the subscriber the option of entering an IPPV event during the current showing by pressing "A" application definable key **252** when the IPPV event is a NVOD or PPD event.

FIG. **29** illustrates an alternative means through which a subscriber may select an IPPV event for purchase rather than selecting individual channels for each IPPV event. As shown an interactive barker **564** allows the subscriber to select an IPPV program title from a list of titles **566** and a time from a list of times **568**. The subscriber may scroll through the lists of titles **566** by pressing up and down arrow keys (not shown) as indicated by up and down arrow indicators **572** and **574**. After selecting a program, an IPPV program information banner **570** then indicates to the subscriber the program price, channel, rating, etc. To scroll the list of times **568**, the subscriber presses left and right arrow keys (not shown) as indicated by left and right arrow indicators **576** and **578**. Much like event barker **544** (FIG. **28**), from barker **564** the subscriber may display a summary of IPPV purchases by pressing "A" application definable key **252** or purchase the selected program by pressing "B" application definable key **252**.

Referring to FIG. **30**, the operation of the countdown mechanism for IPPV purchases is now described. After a countdown barker **556** is displayed confirming the purchase of a future IPPV event, the subscriber is free to change channels to watch another program **580** while awaiting the IPPV event. If a problem occurs in purchasing the desired IPPV event, a message banner **582** will be displayed to indicate to the subscriber the presence of a problem. If the subscriber presses select key **136** in response to banner **582**, a more detailed window **584** will be displayed to indicate to the subscriber how to proceed. Upon exiting window **584** by pressing "C" application definable key **252**, the subscriber will return to event barker **544** if the purchase problem has not been resolved. If the purchase problem has been resolved, an updated countdown barker **586** will be displayed. If no purchase problems are encountered while viewing program **580**, a notification banner **588** will be displayed at least one time period before the beginning of the IPPV event. By pressing select key **136** in response to barker **588**, the subscriber will cause the set-top terminal to display an updated countdown barker **586**. At the time the IPPV event begins, the IPPV event will be selected and displayed as illustrated by display **590**. Along with display **590**, a program information banner **592** may be displayed to indicate to the subscriber that the IPPV event has begun.

Preferred embodiments of the present invention incorporate a method for canceling pending IPPV purchases as illustrated in FIG. **31**. By entering an IPPV summary display **594** from a countdown barker **556** (or any other display) by pressing "A" application definable key **252**, a list **596** of pending and past IPPV purchases is displayed. After using up and down arrow keys **128** to highlight a pending purchase **598**, the subscriber may cancel purchase **598** by pressing "C" application definable key **252**. Once purchase **598** has been canceled, an updated summary display **600** is presented. After a brief period (e.g., 30 seconds) of inactivity, the display will revert to countdown barker **556** (if the IPPV event of barker **556** is still pending) or an event barker **544** for that IPPV channel.

The free preview feature of the present invention is illustrated in FIG. **32**. After selecting an IPPV channel from an interactive program guide display **540** or a normal television display **542**, set-top terminal **6** may display a preview barker **602** showing a free preview of an IPPV event in a preview window **604**. In response to barker **602**, the subscriber may elect to buy the IPPV event by pressing "B" application definable key **252** as indicated by a buy option indicator **606**. Set-top terminal **6** will then display a confirmation barker **552** to confirm the purchase request. In response, the subscriber may confirm the purchase request by pressing "B" key **252** again after which set-top terminal **6** will continue the IPPV purchase in accord with FIG. **28**, or cancel the request by pressing "C" application definable key **252** after which the display will revert to preview barker **602**. If the subscriber does not press "B" key **252** in response to preview barker **602** and the time period for the preview expires, a preview expiration barker **608** will be displayed. Expiration barker **608** allows the subscriber to return to event barker **556** by pressing "C" application definable key **252** or to purchase the IPPV event, and therefore continue to the confirmation barker **552**, by pressing "B" application definable key **252**.

Preferred embodiments of the present invention also provide for the operation of Near-Video-On-Demand (NVOD) programs. NVOD allows a program to be viewed

more frequently than traditional IPPV events. This is accomplished in the present invention by transmitting the same program using two or more sources, each beginning a fixed period of time after the others. For example, transmitting an hour long program on four channels, each fifteen minutes apart, allows the program to be viewed beginning every fifteen minutes. In this way, the video is near on demand—the prospective subscriber only has to wait at most fifteen minutes to view the program.

A pause feature is incorporated into the NVOD feature of the preferred embodiments of the present invention as illustrated in FIG. **33**. The pause feature operates by presenting a pause barker **616** when the subscriber presses pause key **612** while viewing a NVOD event **614**. Pause barker **616** notifies the subscriber that the program is "paused" and provides a countdown timer **618** informing the subscriber when the program will resume. This countdown timer begins with a time equivalent to the delay between consecutive transmissions of the same program. Upon expiration of countdown timer **618**, the pause feature automatically switches to subsequent transmission **622** of the program. In this way, the program appears to have been paused for the fixed period of time. Alternatively, the subscriber can elect to continue viewing current transmission **614** of the program by pressing play key **610** as indicated by play indicator **620**. By pressing play key **610**, pause barker **616** is removed from display, transmission **614** is displayed, and any part of transmission **614** during which pause barker **616** was displayed is lost.

Similarly, NVOD provides skip forward and skip backward capabilities as well. As illustrated in FIG. **34**, pressing fast-forward (FF) key **634** while viewing an nth transmission **614** of an NVOD program causes set-top terminal **6** to tune to (n−1)th transmission **624** of the same NVOD program—that is the transmission which began immediately prior to the nth transmission. Pressing FF key **634** again causes the set-top terminal to select (n−2)th transmission **626** of the NVOD program. Likewise, pressing rewind (REW) key **636** while viewing nth transmission **614** of an NVOD program causes the set-top terminal to tune to (n+1)th transmission **628** of the NVOD program. In instances where the subscriber presses REW key **636** and an (n+2)th transmission has not yet begun, a delay barker **630** is displayed indicating that the NVOD program cannot be skipped backward any further. Delay barker **630** displays a countdown timer **638** indicating to the subscriber the amount of time remaining before the (n+2)th transmission of the NVOD program begins. Pressing REW key **636** again with the delay barker **630** displayed causes the barker to indicate to the subscriber that the program cannot be further skipped backward by blinking the "elapsed time" text **640**.

The present invention also incorporates a message transmission system. Messages may be sent from headend **2** to one or more subscribers at one or more set-top terminals **6**, or may be sent from one subscriber within a household to another (e.g., automatic message from mother to son sent every Monday night at 8:15 p.m.: "take out trash"). The messages may be displayed upon the occurrence of a predetermined action by the subscriber or immediately by overriding whatever channel was previously being viewed by the subscriber. For example, FIG. **35** illustrates the display of an emergency broadcast message **642**. As indicated by select key indicator **644**, the subscriber can press the select key (not shown), or any other key, to get more information regarding the message being displayed. In response to the subscriber pressing select key **136**, set-top terminal **6** may switch to another channel to display more information or display another message. Additionally, messages may be configured to turn on set-top terminal **6** and an attached television or other appliance to automatically display an important message. In this way, a subscriber can be effectively alerted to a crisis situation without the subscriber watching television at the time of the transmission. Messages can also activate a particular service within the set-top terminal. For example, a message can cause the set-top terminal to switch to and display a particular service on the subscriber's television. To indicate the presence of a message in set-top terminal **6**, an LED on the terminal's face may illuminate or an icon may be incorporated into the display screen until a subscriber presses a key or a fixed amount of time has passed.

One skilled in the art will appreciate that the present invention can be practiced by other than the described embodiments, which are presented for purposes of illustration and not of limitation, and the present invention is limited only by the claims which follow.

What is claimed is:

1. An interactive program guide for displaying information regarding a plurality of television programs on an interactive program guide display, said interactive program guide comprising:

a grid having a plurality of cells, each cell corresponding to a television program; and

an indicator for designating a cell, said indicator anchored at a fixed position with respect to said display; wherein:

said grid is moveable with respect to said indicator in two directions in each of two dimensions such that different cells can be designated by said indicator at said fixed position by movement of said grid.

2. The interactive program guide of claim **1** wherein said cells move horizontally and vertically with respect to said indicator.

3. The interactive program guide of claim **1** wherein said cells have a plurality of sizes and said indicator changes size to highlight a cell after said grid is moved.

4. The interactive program guide of claim **1** wherein said cells scroll in at least one of said two dimensions with respect to said indicator.

5. The interactive program guide of claim **1** wherein said indicator comprises a cursor.

6. A system for providing an interactive program guide that displays information regarding a plurality of television programs on an interactive program guide display, said system comprising:

a receiver for receiving said information;

a display driver for generating displayable video output for said display;

a grid control for receiving user inputs; and

a processor for causing said display driver to:

display on said display a grid having a plurality of cells, each cell including at least a portion of said information received by said receiver;

display on said display an indicator for designating a cell, said indicator anchored at a fixed position with respect to said display; and

move said grid on said display in two directions in each of two dimensions with respect to said indicator at said fixed position in accordance with said user inputs received by said grid control.

7. The system of claim **6** wherein said grid can be moved horizontally and vertically with respect to said indicator.

8. The system of claim **6** wherein said cells have a plurality of cell sizes and said indicator can change size to

highlight a cell after said processor causes said display driver to move said grid.

9. The system of claim 6 wherein said indicator comprises a cursor.

10. A system for providing an interactive program guide that displays information regarding a plurality of television programs on an interactive program guide display, said display including a grid of cells, each cell corresponding to a television program, said system comprising:

means for designating a cell on said display at a fixed position with respect to said display; and

means for moving said grid in each of two dimensions with respect to said fixed position such that different cells can be designated by said means for designating by movement of said grid, said movement independent of said means for designating.

11. The interactive program guide of claim 10 wherein said means for moving moves said grid horizontally and vertically with respect to said fixed position.

12. The interactive program guide of claim 10 wherein said means for moving scrolls said cells in at least one of said two dimensions with respect to said fixed position.

13. The interactive program guide of claim 12 wherein said means for moving scrolls said cells horizontally and vertically with respect to said fixed position.

14. A method of designating a cell in a grid of cells, said cells displaying information regarding a plurality of television programs on an interactive program guide display, said method comprising:

designating any cell at only one fixed position on said display;

moving said grid in a first direction in a first dimension to designate a first cell upon said first cell moving into said fixed position;

moving said grid in a second direction in said first dimension to designate a second cell upon said second cell moving into said fixed position;

moving said grid in both said first direction in said first dimension and said first direction in said second dimension to designate a third cell upon said third cell moving into said fixed position; and

moving said grid in both said second direction in said first dimension and said second direction in said second dimension to-designate a fourth cell upon said fourth cell moving into said fixed position, wherein said first and second directions of said first dimension are opposite each other.

15. The method of claim 14 wherein said moving said grid in both said first direction in said first dimension and said first direction in said second dimension comprises moving said grid horizontally rightward and vertically downward with respect to said fixed position.

16. The method of claim 14 wherein said moving said grid in both said second direction in said first dimension and said second direction in said second dimension comprises scrolling said cells horizontally leftward and vertically upward with respect to said fixed position.

17. An interactive program guide for displaying information regarding a plurality of television programs on an interactive program guide display, said interactive program guide comprising:

a grid having a plurality of cells, each cell corresponding to a television program; and

an indicator having a fixed position on said display; wherein:

said grid is moveable in each of two dimensions with respect to said indicator, said indicator highlighting a cell when said cell is positioned at said fixed position, said grid movement independent of said indicator fixed position.

18. The interactive program guide of claim 17 wherein said indicator comprises a cursor.

19. Software on a computer readable medium for designating a cell in a grid of cells, said cells displaying information regarding a plurality of television programs on an interactive program guide display, said software comprising;

establishing only one fixed position on said display at which cells are designated;

allowing said grid to move with respect to said fixed position in each of two directions in each of two dimensions; and

designating a cell when said cell is positioned at said established position.

20. A method of designating a cell in a grid of cells, said cells displaying information regarding a plurality of television programs on an interactive program guide display, said method comprising;

designating a cell on said display at a fixed position with respect to said display; and

moving said grid in each of two dimensions with respect to said fixed position such that different cells can be designated at said fixed position by said moving of said grid, said moving independent of said designating.

* * * * *

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Voit et al.

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(45) **Date of Patent: Sep. 28, 2004**

(54) **CUSTOMER PREMISES EQUIPMENT FOR VERTICAL SERVICES INTEGRATION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 111 days.

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Related U.S. Application Data

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(51) **Int. Cl.**[7] **H04J 3/16**
(52) **U.S. Cl.** **370/252**; 370/469; 709/230
(58) **Field of Search** 370/252, 231, 370/352, 389, 395, 401, 402, 412, 413, 428, 465, 466, 467, 469; 709/225, 227, 230, 236, 223; 376/351, 392, 395.32, 395.5

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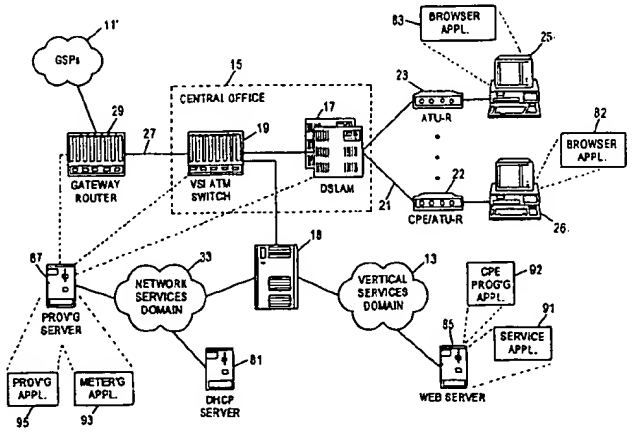
(57) **ABSTRACT**

Offering vertical services to subscribers and service providers is an avenue to immediately improve the competitiveness of digital subscriber line access service, for example of the type offered by a local exchange carrier. To deliver high-quality vertical services, however, the underlying ADSL Data Network (ADN) or the like needs to establish Quality of Service (QoS) as a core characteristic and offer an efficient mechanism for insertion of the vertical services. The inventive network architecture introduces QoS into the ADN, in a manner that enables the delivery of sophisticated and demanding IP-based services to subscribers, does not affect existing Internet tiers of service, and is cost-effective in terms of initial costs, build-out, and ongoing operations. The architecture utilizes a switch capable of examining and selectively forwarding packets or frames based on higher layer information in the protocol stack, that is to say on information that is encapsulated in the layer-2 information utilized to define normal connectivity through the network. The switch enables segregation of upstream traffic by type and downstream aggregation of Internet traffic together with traffic from a local vertical services domain. Customer Premises Equipment (CPE) located between the ADN and customer premises data equipment examines frames received from the data equipment and modifies the frames according to the destination of the frames' payloads. This CPE also enforces QoS guarantees in the upstream direction and security-related access control lists.

27 Claims, 15 Drawing Sheets



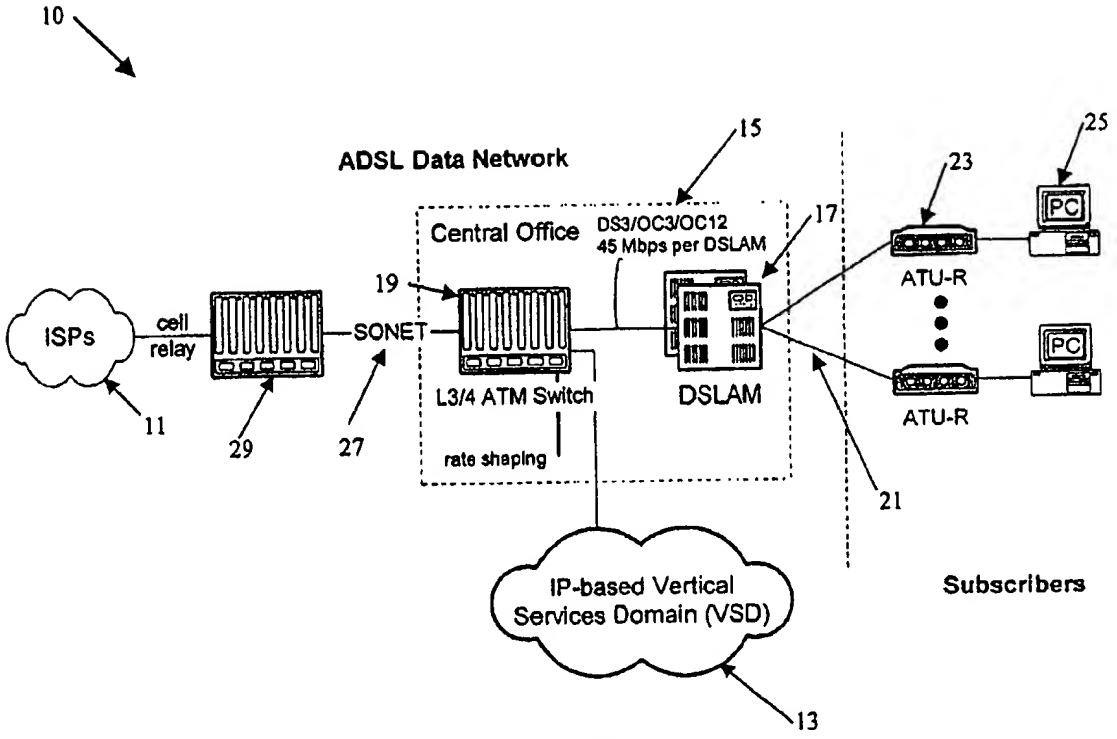

10
ADSL Data Network
15
Central Office
DS3/OC3/OC12
45 Mbps per DSLAM
17
19
23
25
ATU-R
PC
ISPs
cell
relay
SONET
L3/4 ATM Switch
DSLAM
ATU-R
PC
11
29
27
rate shaping
21
IP-based Vertical
Services Domain (VSD)
Subscribers
13

FIG. 1

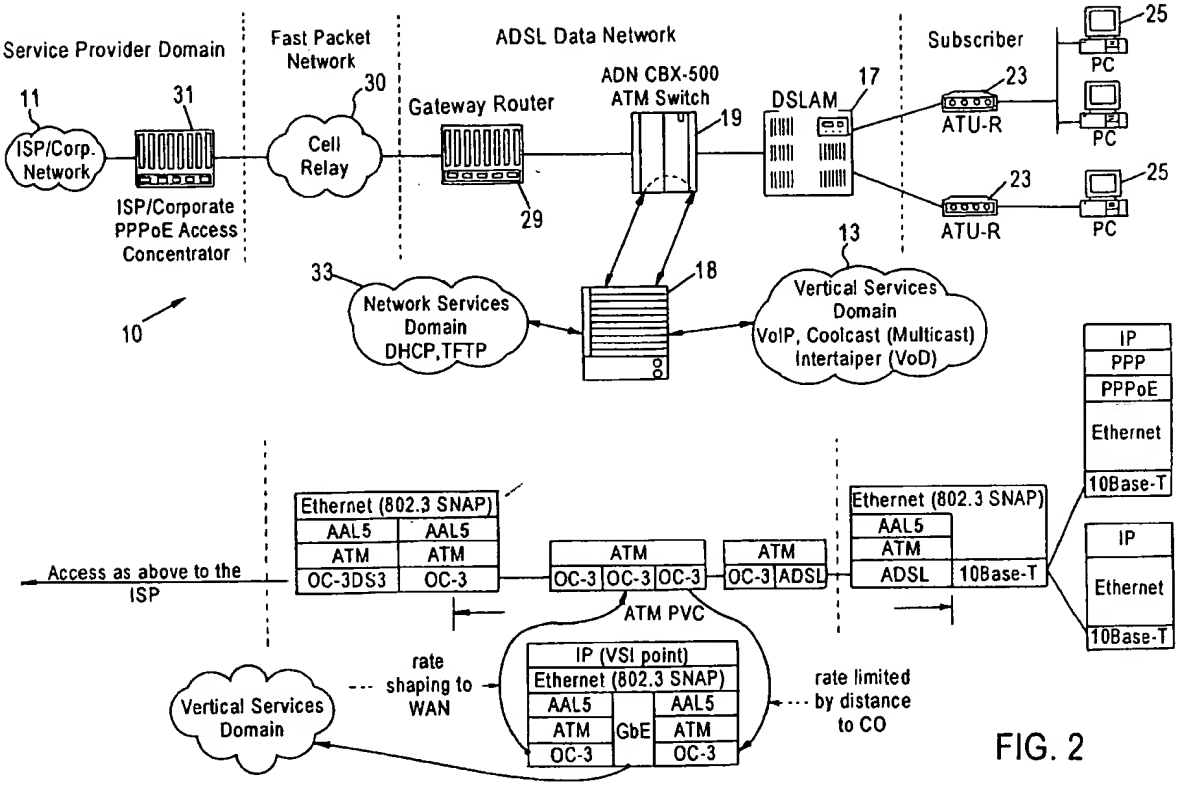

Service Provider Domain
Fast Packet Network
ADSL Data Network
Subscriber
11
31
30
Gateway Router
ADN CBX-500 ATM Switch
19
DSLAM
17
23
25
PC
ATU-R
ISP/Corp. Network
Cell Relay
29
ISP/Corporate PPPoE Access Concentrator
10
33
Network Services Domain DHCP,TFTP
18
13
Vertical Services Domain VoIP, Coolcast (Multicast) Intertaiper (VoD)
IP
PPP
PPPoE
Ethernet
10Base-T
Ethernet (802.3 SNAP)
AAL5
ATM
OC-3DS3
OC-3
Access as above to the ISP
ATM PVC
OC-3
ADSL
IP (VSI point)
GbE
rate shaping to WAN
rate limited by distance to CO
Vertical Services Domain

FIG. 2

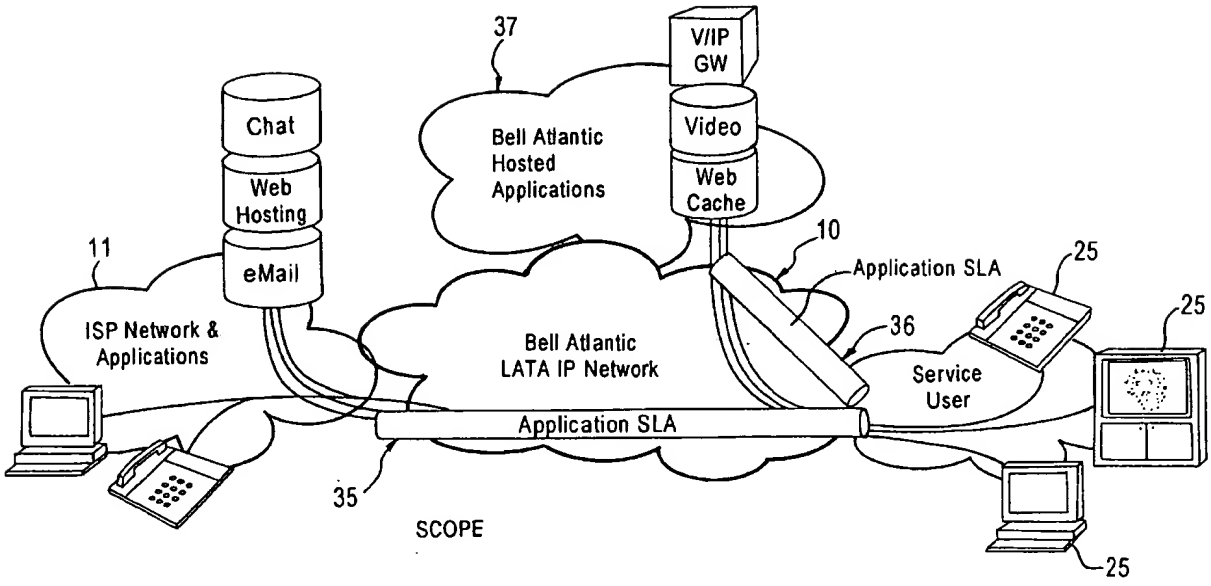

37
V/IP GW
Chat
Web Hosting
eMail
Bell Atlantic Hosted Applications
Video
Web Cache
11
10
Application SLA
25
25
ISP Network & Applications
Bell Atlantic LATA IP Network
36
Service User
Application SLA
35
SCOPE
25

FIG. 3

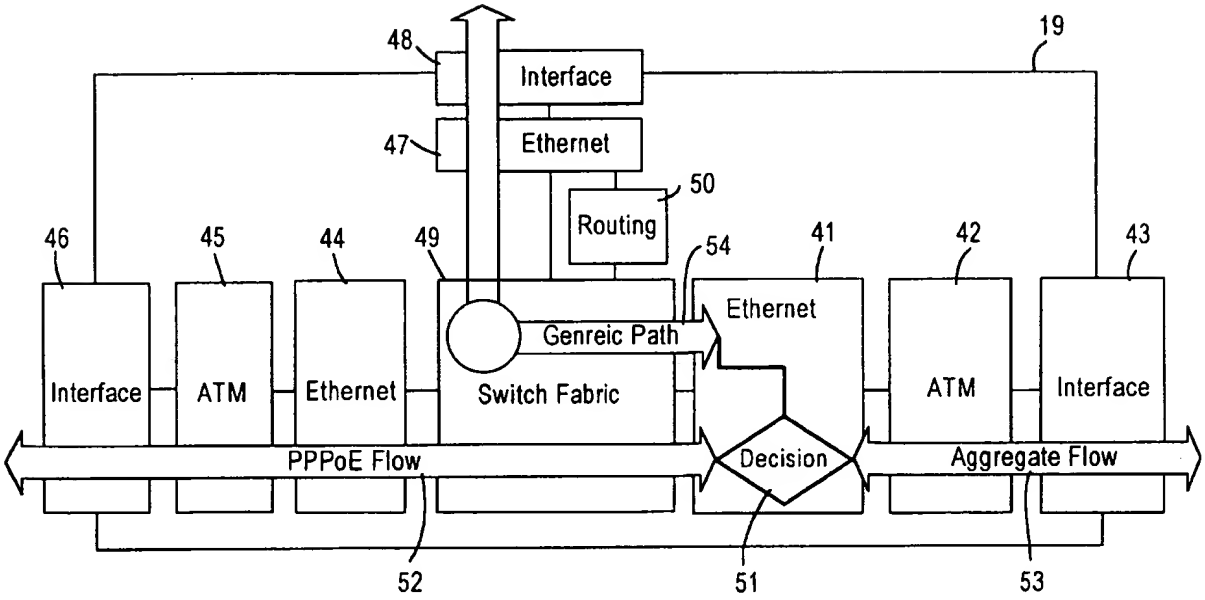

48
Interface
19
47
Ethernet
50
Routing
46
45
44
49
54
41
42
43
Ethernet
Genreic Path
Interface
ATM
Ethernet
Switch Fabric
ATM
Interface
PPPoE Flow
Decision
Aggregate Flow
52
51
53

FIG. 4

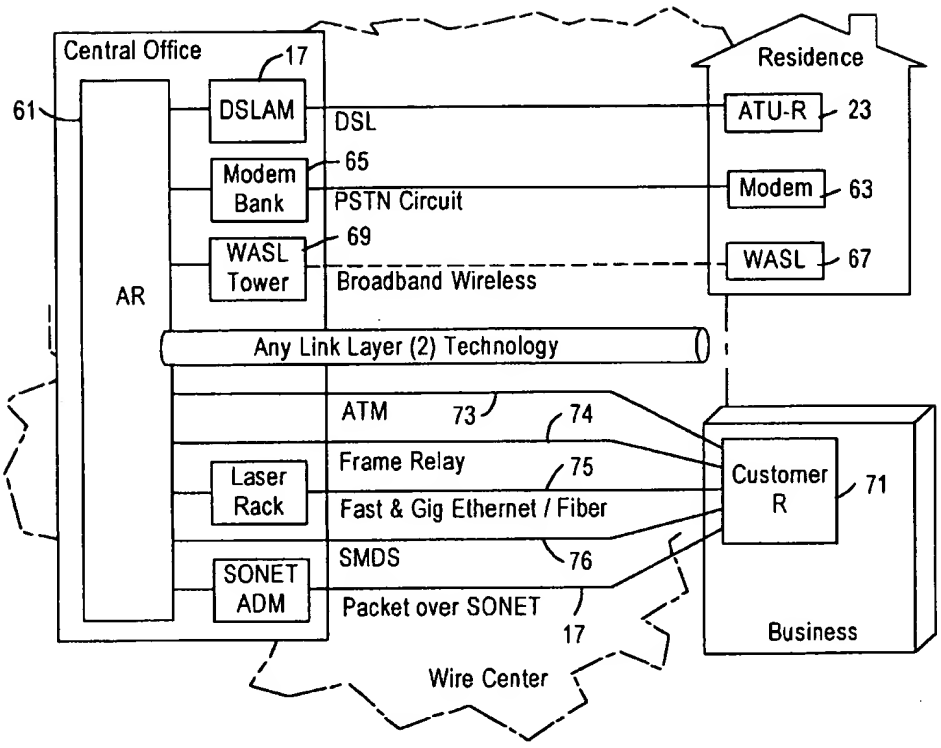

Central Office
17
61
DSLAM
DSL
Modem Bank
65
PSTN Circuit
WASL Tower
69
Broadband Wireless
AR
Any Link Layer (2) Technology
ATM
73
74
Frame Relay
75
Laser Rack
Fast & Gig Ethernet / Fiber
SMDS
76
SONET ADM
Packet over SONET
17
Wire Center
Residence
ATU-R
23
Modem
63
WASL
67
Customer R
71
Business

FIG. 5

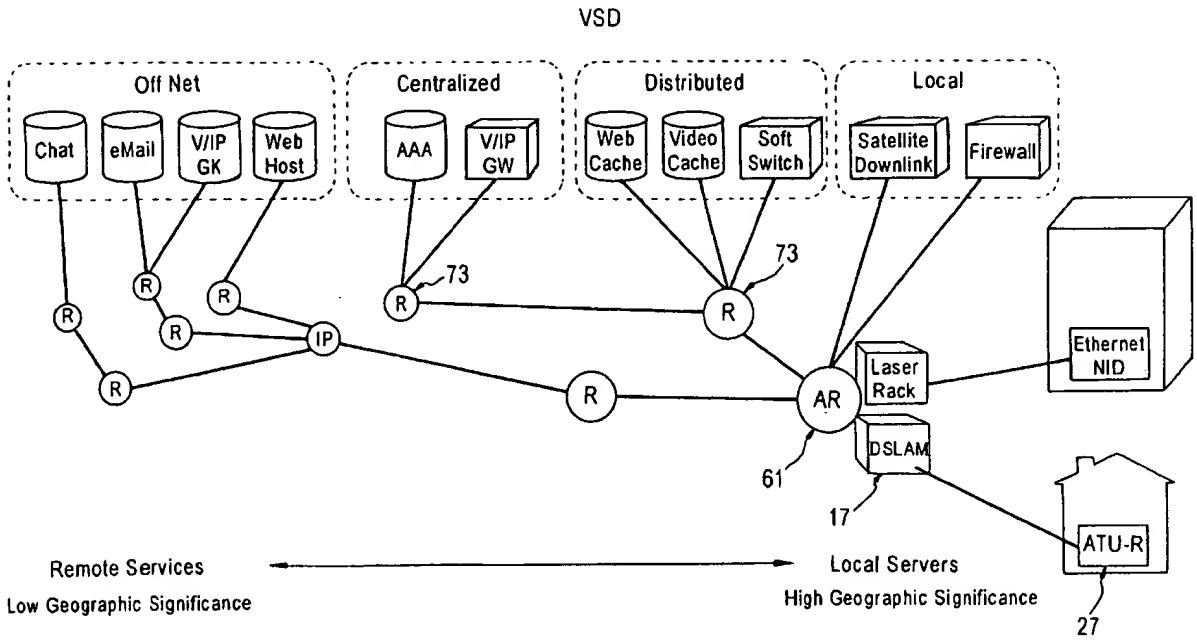

VSD
Off Net
Chat
eMail
V/IP GK
Web Host
Centralized
AAA
V/IP GW
Distributed
Web Cache
Video Cache
Soft Switch
Local
Satellite Downlink
Firewall
R
IP
73
AR
Laser Rack
DSLAM
Ethernet NID
ATU-R
61
17
27
Remote Services
Low Geographic Significance
Local Servers
High Geographic Significance

FIG. 6

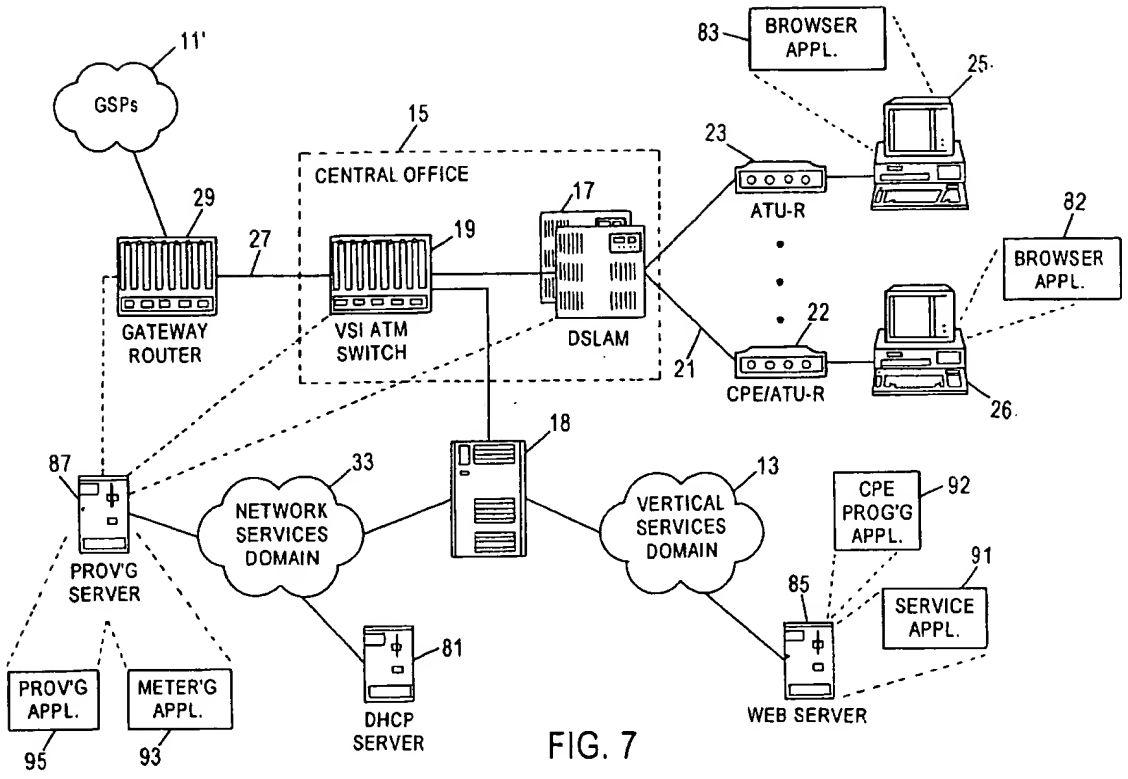

11'
GSPs
15
CENTRAL OFFICE
29
27
19
17
83
BROWSER APPL.
25
23
ATU-R
82
BROWSER APPL.
GATEWAY ROUTER
VSI ATM SWITCH
DSLAM
22
21
CPE/ATU-R
26
87
18
33
NETWORK SERVICES DOMAIN
13
VERTICAL SERVICES DOMAIN
CPE PROG'G APPL.
92
91
SERVICE APPL.
85
PROV'G SERVER
81
DHCP SERVER
WEB SERVER
PROV'G APPL.
METER'G APPL.
95
93

FIG. 7

FIG. 8

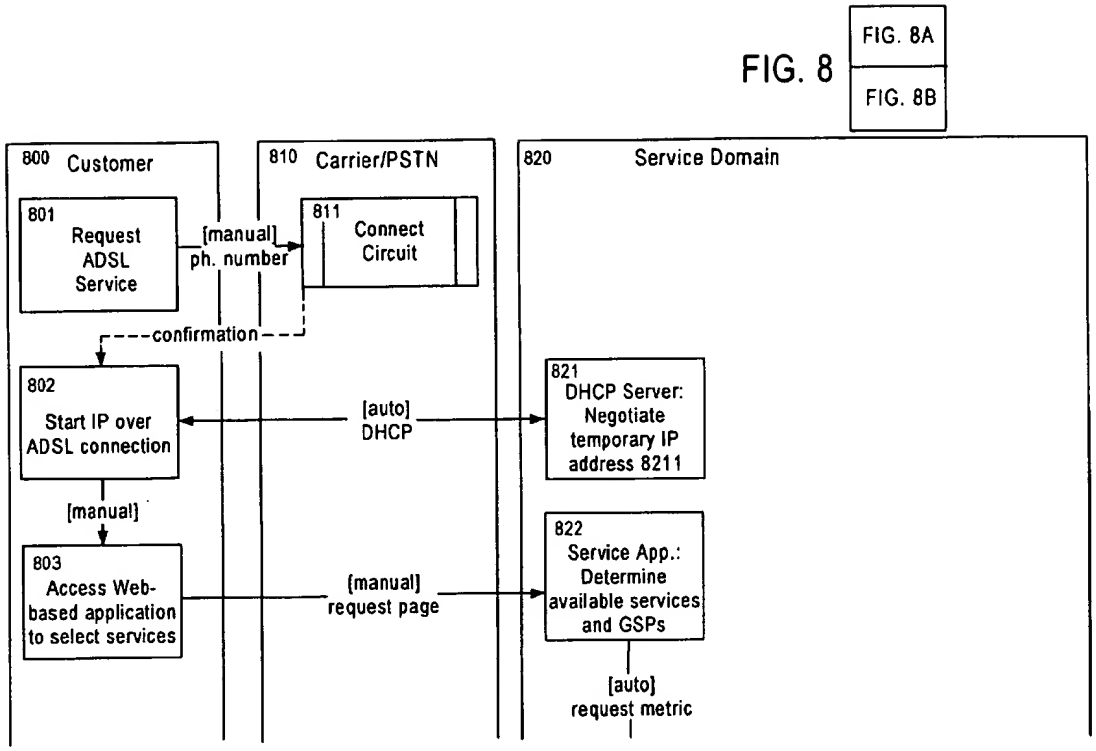


FIG. 8A
FIG. 8B
800 Customer
810 Carrier/PSTN
820 Service Domain
801 Request ADSL Service
[manual] ph. number
811 Connect Circuit
confirmation
802 Start IP over ADSL connection
[auto] DHCP
821 DHCP Server: Negotiate temporary IP address 8211
[manual]
803 Access Web-based application to select services
[manual] request page
822 Service App.: Determine available services and GSPs
[auto] request metric

FIG. 8A

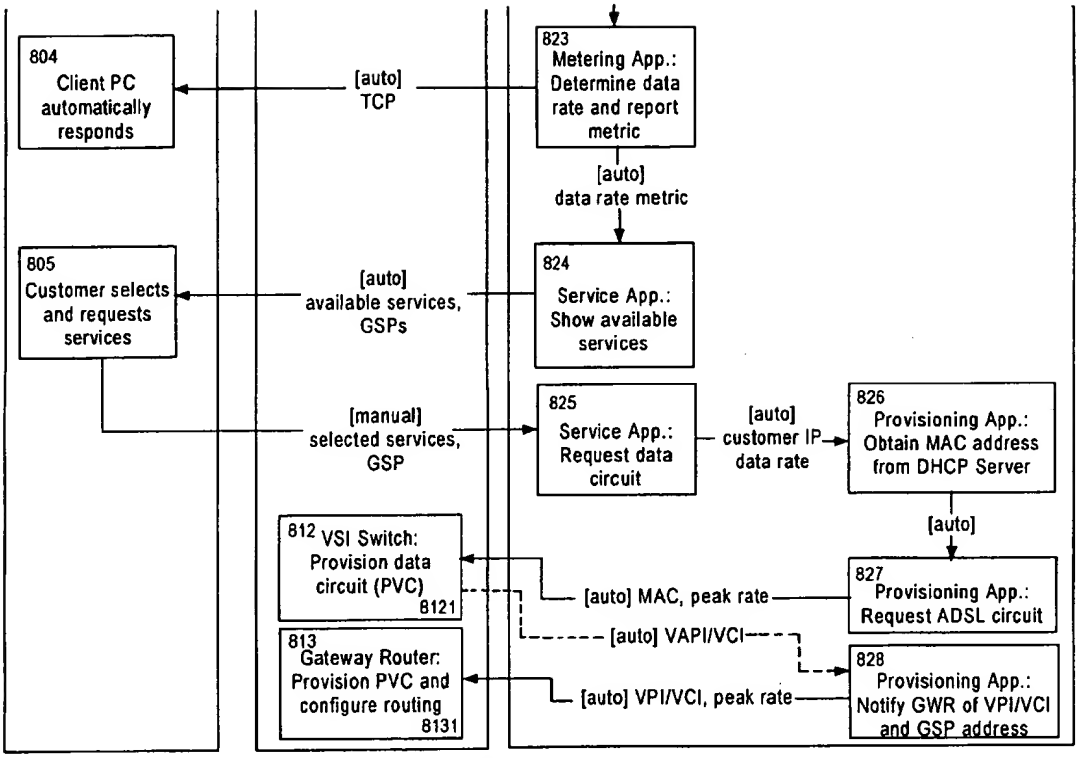

804
Client PC automatically responds
[auto] TCP
823
Metering App.: Determine data rate and report metric
[auto] data rate metric
805
Customer selects and requests services
[auto] available services, GSPs
824
Service App.: Show available services
[manual] selected services, GSP
825
Service App.: Request data circuit
[auto] customer IP data rate
826
Provisioning App.: Obtain MAC address from DHCP Server
[auto]
812 VSI Switch: Provision data circuit (PVC)
8121
[auto] MAC, peak rate
827
Provisioning App.: Request ADSL circuit
[auto] VAPI/VCI
813
Gateway Router: Provision PVC and configure routing
8131
[auto] VPI/VCI, peak rate
828
Provisioning App.: Notify GWR of VPI/VCI and GSP address

FIG. 8B

922 924 TABLE 920 926

NETWORK	MASK	ETHERTYPE
0.0.0.0	0	PPPoE
192.168.1.0	{Class C}	ETHERTYPE A
192.168.5.32	{subnet mask}	ETHERTYPE B
...	...	...

932 TABLE 930 934

MAC ADDRESS	ALLOWED CONNECTION TYPES
{48 bits}	{ACL-type syntax}
...	...

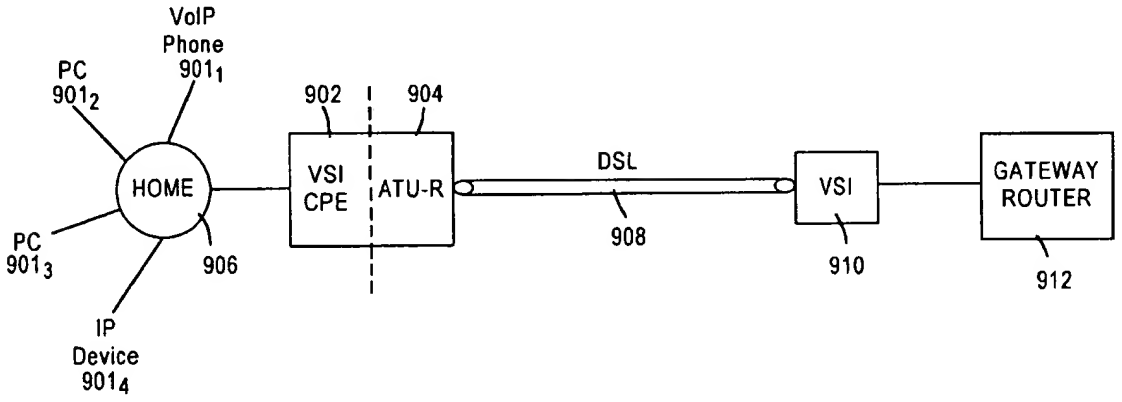


FIG. 9

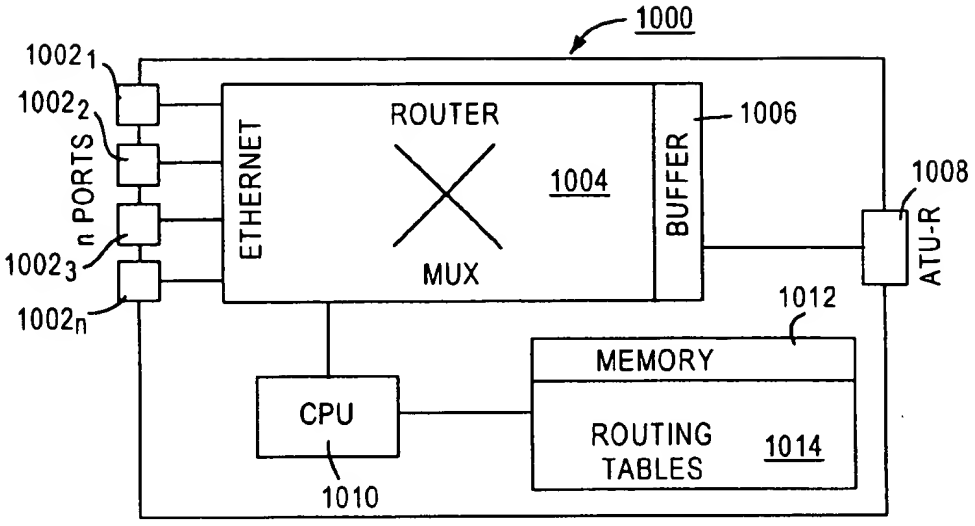

1000
1002_1
1002_2
n PORTS
1002_3
1002_n
ETHERNET
ROUTER
1004
MUX
BUFFER
1006
1008
ATU-R
1012
MEMORY
ROUTING TABLES
1014
CPU
1010

FIG. 10

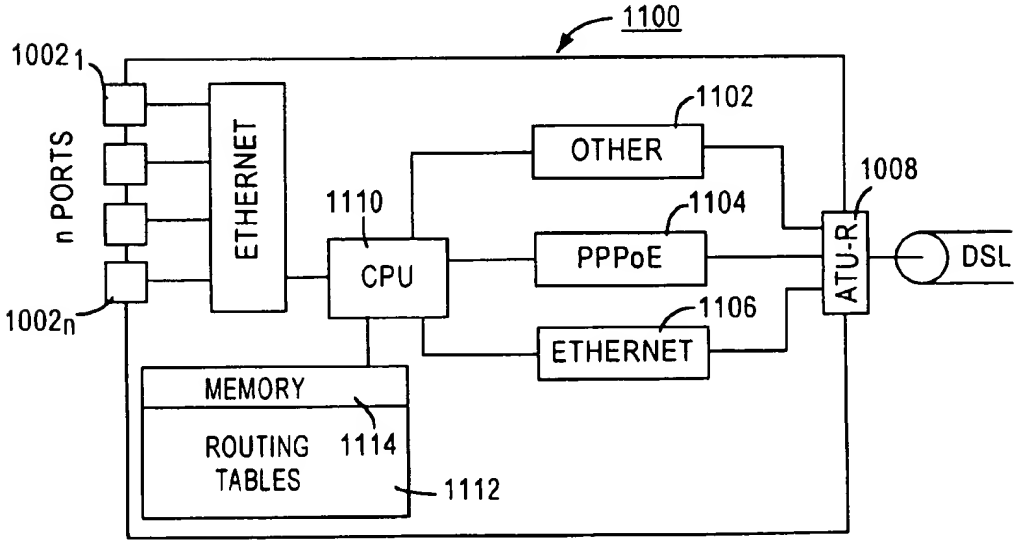

1100
1002_1
n PORTS
1002_n
ETHERNET
1110
CPU
1102
OTHER
1104
PPPoE
1106
ETHERNET
1008
ATU-R
DSL
MEMORY
ROUTING TABLES
1114
1112

FIG. 11

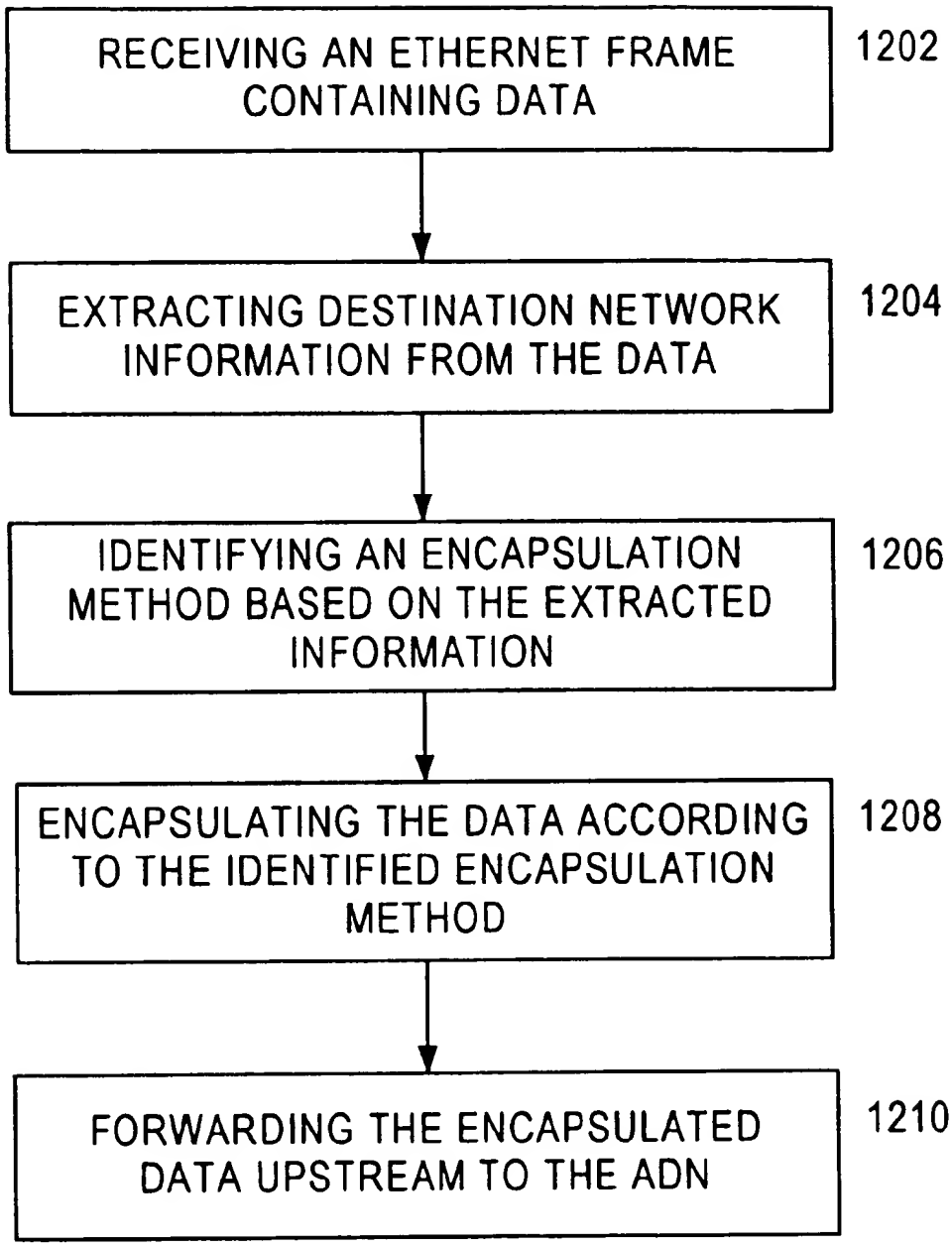

RECEIVING AN ETHERNET FRAME CONTAINING DATA
1202
EXTRACTING DESTINATION NETWORK INFORMATION FROM THE DATA
1204
IDENTIFYING AN ENCAPSULATION METHOD BASED ON THE EXTRACTED INFORMATION
1206
ENCAPSULATING THE DATA ACCORDING TO THE IDENTIFIED ENCAPSULATION METHOD
1208
FORWARDING THE ENCAPSULATED DATA UPSTREAM TO THE ADN
1210

FIG. 12

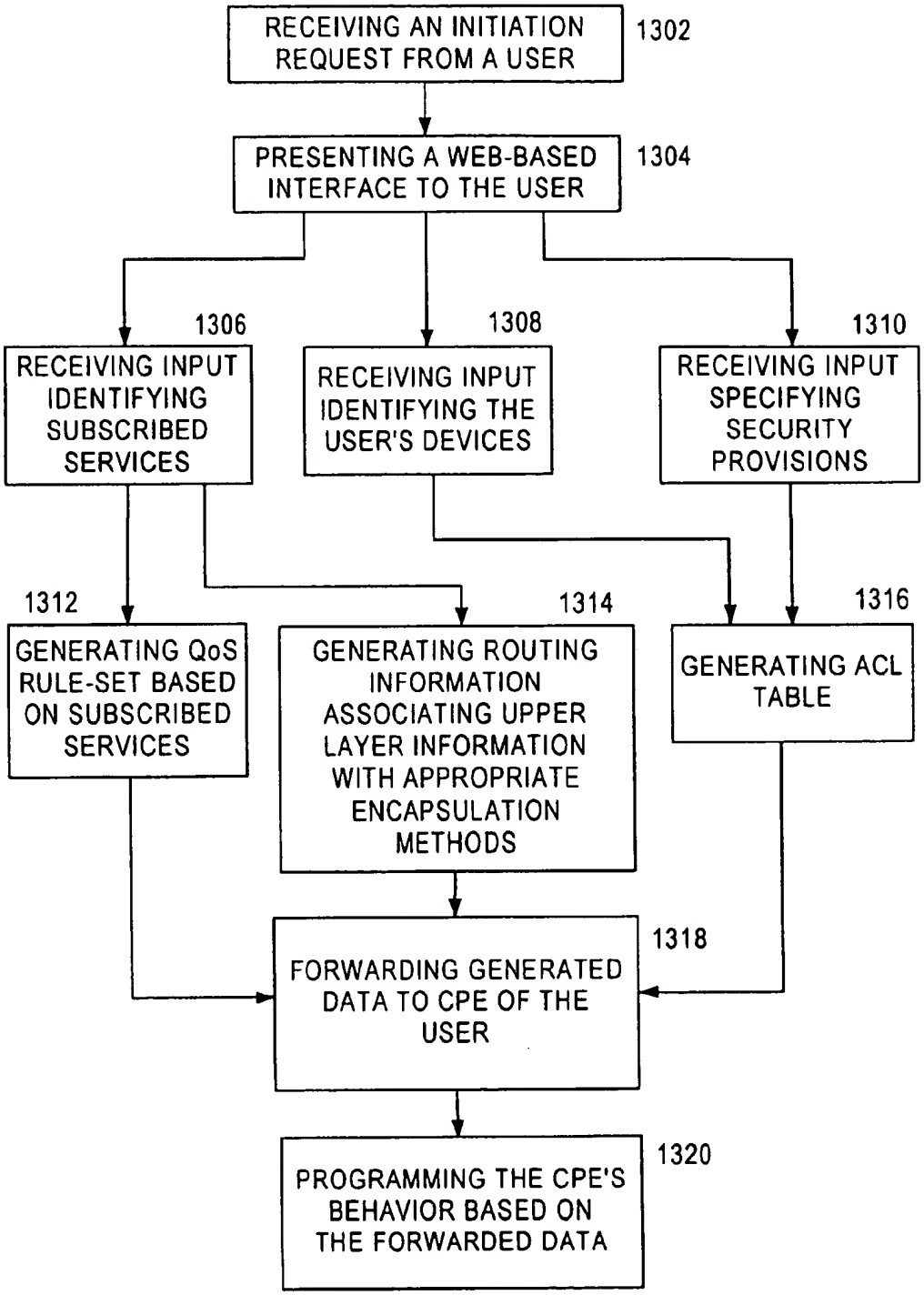

RECEIVING AN INITIATION REQUEST FROM A USER
1302
PRESENTING A WEB-BASED INTERFACE TO THE USER
1304
1306
RECEIVING INPUT IDENTIFYING SUBSCRIBED SERVICES
1308
RECEIVING INPUT IDENTIFYING THE USER'S DEVICES
1310
RECEIVING INPUT SPECIFYING SECURITY PROVISIONS
1312
GENERATING QoS RULE-SET BASED ON SUBSCRIBED SERVICES
1314
GENERATING ROUTING INFORMATION ASSOCIATING UPPER LAYER INFORMATION WITH APPROPRIATE ENCAPSULATION METHODS
1316
GENERATING ACL TABLE
1318
FORWARDING GENERATED DATA TO CPE OF THE USER
1320
PROGRAMMING THE CPE'S BEHAVIOR BASED ON THE FORWARDED DATA

FIG. 13

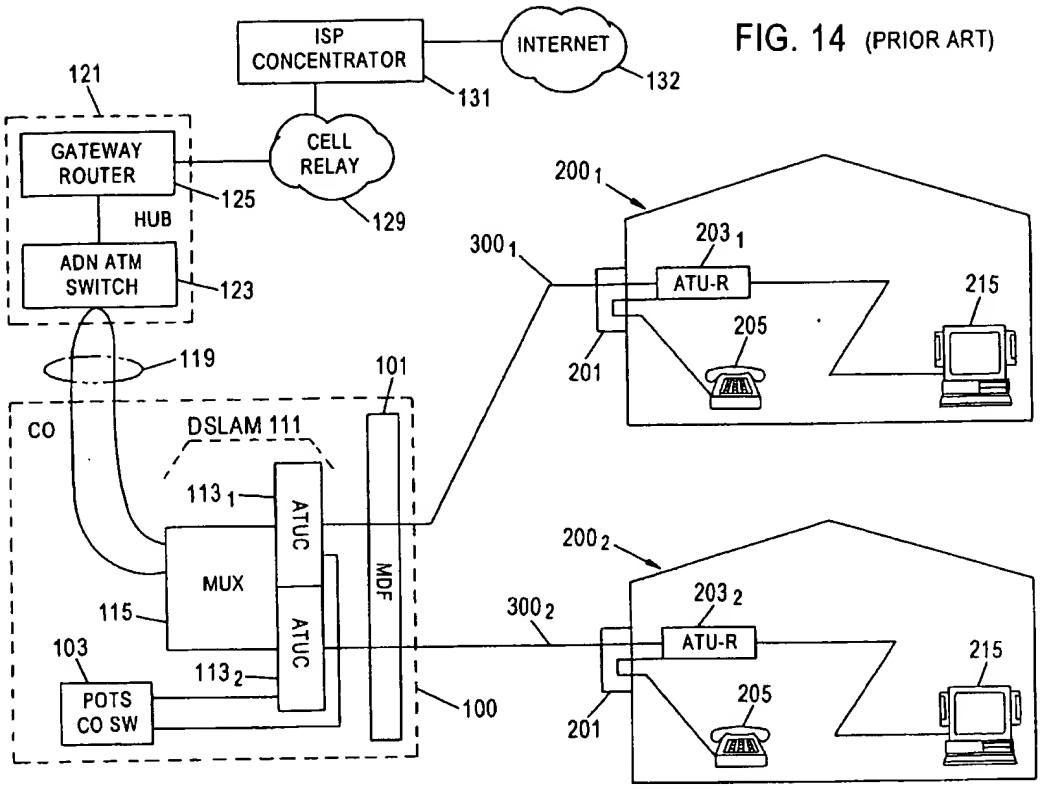
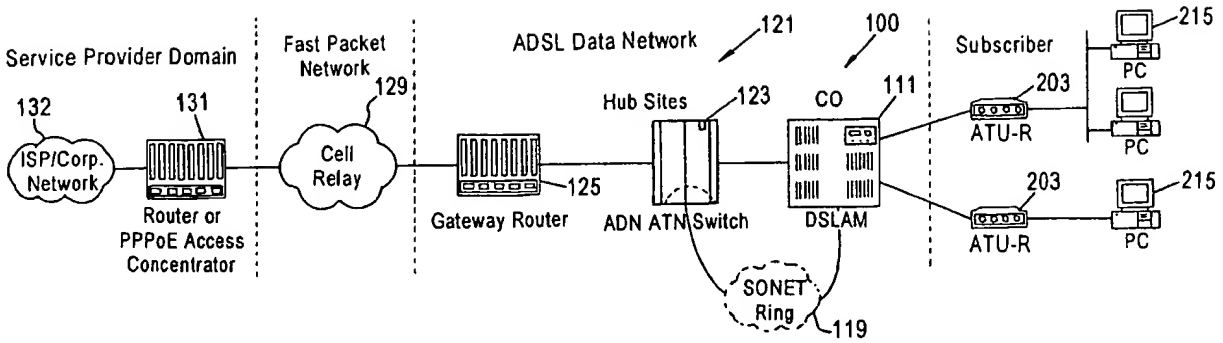


FIG. 14 (PRIOR ART)



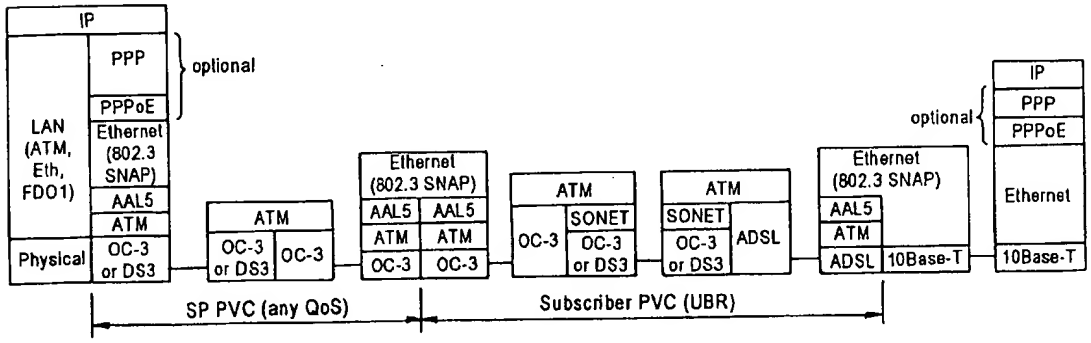


FIG. 15 (PRIOR ART)

CUSTOMER PREMISES EQUIPMENT FOR VERTICAL SERVICES INTEGRATION

RELATED APPLICATIONS

This application is a continuation in part of U.S. patent application Ser. No. 09/635,695, filed Aug. 10, 2000 entitled "SUPPORT FOR QUALITY OF SERVICE AND VERTICAL SERVICES IN DIGITAL SUBSCRIBER LINE DOMAIN" and U.S. patent application Ser. No. 09/652,140, filed Aug. 31, 2000 entitled, "AUTOMATED SERVICE PROVISIONING IN COMBINATION OF VERTICAL SERVICES AND DIGITAL SUBSCRIBER LINE DOMAINS", the disclosures of which are incorporated herein entirely by reference.

FIELD OF THE INVENTION

Certain concepts involved in the present invention relate to techniques for implementing data communication services, for example in a local access network utilizing digital subscriber line technology, to support quality of service (QoS) and local introduction of vertical services. Other concepts involved in the present invention relate to techniques for automatically provisioning services through such a network. Other concepts involved in the present invention relate to placement of protocol stack shims on equipment that is separate from the devices used by a customer.

BACKGROUND

Modern society continues to create exponentially increasing demands for digital information and the communication of such information between data devices. Local area networks use a network, cable or other media to link stations on the network for exchange of information in the form of packets of digital data. These networks have proven quite successful in providing data communications in commercial applications. However, the common local area network architectures require installation of specialized wiring and use of specific wiring topologies. For example, the most popular network protocols, such as Ethernet, require special rules for the wiring, for example with regard to quality of wire, range of transmission and termination. Furthermore, to extend communications to a wider domain still requires connection of at least one node of the local area network out to a wider area network, such as the network of an Internet Service Provider (ISP). High speed links enabling such wide area access from a LAN domain, for example using T1 lines, are quite expensive and justified only for hi-end commercial users.

The most common form of computer-to-computer communication in use today, particularly for wide area communications, still relies on modems and analog telephone network connections. The telephone-based operation provides the voice grade analog modem a unique power, the necessary connections are virtually ubiquitous. Such modems can communicate via almost any telephone line or wireless telephone (e.g. cellular) to any other such telephone connection, virtually anywhere in the world. The telephone network, however, was designed to provide approximately 3.3 kHz of analog voice bandwidth. Consequently, the data rates that are possible through the telephone network are quite low. Even with a variety of recent enhancements, the data speeds remain at or below 56 kbps.

Integrated Services Digital Network (ISDN) offers somewhat faster data communications and the capacity for concurrent data and voice telephone services. The 160 kb/s capacity carries two bearer (B) channels, each at 64 kb/s, one data (D) channel at 16 kb/s and overhead information in a 16 kb/s embedded operations channel (EOC). The two B-channels may be used separately, for example, for one voice telephone call and one data communication session. The D-channel typically is used for signaling, for call set-up and the like. Some applications allow aggregation of the channels, to combine the B-channels and possibly the D-channel to provide data communications up to the combined rate of 144 kb/s. However, these data rates offered by ISDN already are too slow for many multimedia applications. The high-speed and wide availability of modern personal computers (PCs) continually gives rise to ever more sophisticated multimedia applications. Communications for such applications, typically between the PC and the Internet, already are driving the need for speed to rates far above those available on normal ISDN lines.

A number of technologies are being developed and are in early stages of deployment, for providing substantially higher rates of data communication, for example ranging form 640 kb/s to 7.1 Mb/s. For example, cable television companies are now beginning to offer 'cable modem' services, which allow customers to communicate data over available bandwidth on the coaxial cable of a cable television network. After considering several other options, a number of the local telephone carriers are working on enhancements to their existing copper-wire loop networks, based on various xDSL technologies.

The term xDSL here is used as a generic term for a group of higher-rate digital subscriber line communication schemes capable of utilizing twisted pair wiring from an office or other terminal node of a telephone network to the subscriber premises. Examples under various stages of development include ADSL (Asymmetrical Digital Subscriber Line), HDSL (High data rate Digital Subscriber Line) and VDSL (Very high data rate Digital Subscriber Line).

The telephone carriers originally proposed use of ADSL and similar high-speed technologies to implement digital video services, for example in networks sometimes referred to as video 'dialtone' networks. The ADSL line technology provided a mechanism for high-speed transport of MPEG encoded video information to video terminal devices in the customers' homes. Examples of such ADSL-based video dialtone networks are disclosed in U.S. Pat. Nos. 5,247,347, 5,410,343 and 5,621,728. The carriers are now deploying a range of xDSL data services targeted at high-speed Internet access and high-speed access to private data networks. U.S. Pat. No. 5,790,548 to Sistanizadeh et al. discloses an example of an ADSL based data network, e.g. for high-speed access to the Internet and to corporate LANs.

The current design goals of DSL data networks for Internet access do not support high-end vertical services, that is to say services demanding IP-based applications that require assurance of some level of quality of service (QoS). For example, packet-switched Voice over IP (VoIP) requires low latency, low jitter (i.e., a relatively constant bit rate), and non-correlated packet loss. Streaming video has similar requirements, and in addition, requires high bandwidth. DSL data networks designed to support high speed Internet and Intranet access have been optimized to support traffic that is bursty and is not sensitive to latency or jitter. For example, current implementations supporting ATM cell traffic employ the Unspecified Bit Rate (UBR) class of service, which does not provide any bandwidth or delay guarantees. Consequently, transport of video materials through such

DSL data networks inflicts video delays, loss of audio/video synchronization, and image fragmentation.

Furthermore, lengthy bandwidth intensive sessions for video or other broadband applications may degrade the throughput to all other subscribers served through a shared node, such as a gateway router or a concentrated link. For two-way video, upstream will have even worse quality and throughput problems, due to the best effort nature of the DSL data network implemented for Internet access and because the upstream bandwidth is significantly less than that of the downstream channel.

To appreciate the situation and problems, it may be helpful here to consider an ADSL data implementation of a local access network, as a representative example, in somewhat more detail. FIG. **14** is a block diagram of a typical ADSL data network of the type currently in-use by a number of incumbent and competitive local exchange carriers to provide high-speed access to Internet Service Providers (ISPs) and thus to the Internet. FIG. **15** provides an alternative functional illustration of the elements of such a network. Of particular note, FIG. **15** shows the various protocol stacks in association with the appropriate network elements.

As shown in FIG. **14**, a central office (CO) **100** provides plain old telephone service (POTS) and digital subscriber line data service for a number of customers. For purposes of discussion, assume that the equipment at each of the various customer premises **200** connects directly to the CO **100** via twisted pair type copper wiring **300**. In an actual implementation, many customers may connect through such wiring to a remote terminal linked to the CO via optical fiber.

At each customer premises **200** in our example, the copper loop **300** carrying both the POTS and ADSL signals connects through a Network Interface Device (NID) **201** placed at the side of the home. A two pair loop is installed from the NID to the location where the ADSL unit **203**, typically an ATU-R modem, is located in the home. One pair connects all of the signals on the line **300** from the NID **201** to the ADSL modem **203**. Within the ATU-R type modem **203**, a passive splitter/combiner type filter segregates the POTS signal and the data signals. The POTS signal is transmitted over the second twisted pair back to the NID **201**. The POTS line is then connected to the in-home wiring extensions at the NID **201**, for distribution to one or more standard telephone devices **205** in the home.

Within the ATU-R type ADSL modem **203**, the downstream coded ADSL signal is demodulated and decoded to an appropriate data interface protocol for connection to the PC **215**. The PC **215** or other data device (FIG. **15**) also sends data to the ADSL modem **203**. The modem **203** modulates the upstream data and transmits appropriate signals over the line 300_1 or 300_2 to the corresponding modem 113_1 or 113_2 in the CO **100** (FIG. **14**). The ATU-R interface may support bridging, such that multiple users can share the ADSL modem **203**, for two-way data communication through the CO **100**.

The lines **300** for the customer premises **200** connect through the main distribution frame (MDF) **101** to a Digital Subscriber Line Access Multiplexer (DSLAM) **111**. The DSLAM includes a bank of ADSL terminal units of the type intended for central office applications, identified as ATU-Cs **113**. The DSLAM also includes a multiplexer/demultiplexer (MUX) **115**.

Within the DSLAM **111**, each customer line **300** connects to an assigned ADSL terminal unit **113** in the central office (ATU-C). In the example illustrated, the first customer's line 300_1 connects through the MDF **101** to a first ATU-C 113_1 in the CO **100**. The second customer's line 300_2 connects through the MDF **101** to a second ATU-C 113_2 in the CO **100**. The ATU-C type ADSL units **113** include appropriate frequency dependent combiner/splitters, for segregating out the voice telephone traffic. Thus each ADSL unit **113** provides a connection for telephone traffic from the associated line **300** to the POTS switch **103**.

The ADSL units **113** in the CO (ATU-Cs) essentially act as modulator/demodulators (modems) for sending and receiving data over the subscriber telephone lines **300**. On the network side, each of the ATU-Cs **113** connects to the MUX **115**. The MUX **115** multiplexes and demultiplexes the upstream and downstream data for the ADSL modems **113** and provides a connection to a high-speed link **119**. Through subtending, the MUX **115** may also provide a data concentration for the communications over the link **119**.

In a typical implementation, the concentrated data communications utilize a DS-3 link **119**. However, because of increasing traffic demands, it is becoming necessary to upgrade the link **119** to SONET optical fiber, such as OC-3 or in some cases even OC-12. The link **119** provides two-way data communication between the central office **100** and a data hub **121**. In practice, this is a relatively long or wide area link using expensive interoffice facilities.

On the upstream side, the high-speed interoffice link **119** terminates on an ATM switch **123** for the ADSL data network (ADN). Although only one link **119** appears in the drawing, the asynchronous transfer mode (ATM) switch **123** will typically service a number of DSLAMs **111** in various end offices via similar DS or OC links. The ATM switch **123**, in turn, provides a high-speed connection to a gateway router **125** coupled to an ATM cell relay network **129**. Typically, the ATM switch **123** will aggregate traffic from a number of such links **119** onto an OC-3 or higher rate SONET link to the router **125**. The router **125** and the cell relay network **129** enable transport of ATM cells for the subscribers to and from equipment of one or more Internet Service Providers (ISPs), shown by way of example as a concentrator **131** coupled to the public packet switched network commonly known as the Internet **132**.

The illustrated local access type ADN network provides ATM cell transport from a customer premises **200** to the ISP concentrator **131**. The ATM cells serve as the layer-2 routing or switching protocol for the lowest level definition of connectivity between two points of the network. Higher level protocols ride within the ATM cells.

The ATU-Rs **203** and the customer premises data equipment **215** connect via an Ethernet coupler. The customers' equipment communicates across the ADSL data network utilizing Ethernet, and the wide area communication involves transport of Internet protocol information typically in TCP/IP frames within Ethernet frames. The Ethernet frames carrying the TCP/IP frames are adapted into ATM cells. Attention is directed to the protocol stacks illustrated in the lower half of FIG. **15**.

To efficiently provide cell relay, each customer is assigned an ATM virtual circuit that extends from the ATU-R **203** in the respective customer premises **200** to the gateway router **125**. Although it was originally envisioned that ATM would support switched logical channels or virtual circuits, to date, such logical switching has proven impractical to implement and administer. Consequently, current practical ATM networks actually utilize permanent virtual circuits, not switched virtual circuits. For a given subscriber, the carrier therefore provisions an ATM permanent virtual circuit from

the ATU-R **203** to the gateway router **125**. The carrier programs one or more nodes along the path of that logical circuit, particularly the DSLAM **111**, to regulate traffic on the virtual circuit to the upstream and downstream rates corresponding to the grade of service to which the particular customer subscribers. All data traffic for the subscriber goes over the entire length of the permanent virtual circuit, and most if not all nodes along that path limit that traffic to the rates of the subscription as defined in the provisioning data.

The virtual circuit may be thought of as a solid pipe. All traffic passes through the entire length of the pipe-like virtual circuit, regardless of how many switches or other nodes the circuit passes through. The layer-2 protocol defining the circuit carries all of the higher level traffic end-to-end. Higher layer protocols are visible only at the ends of the pipe. Hence, any traffic flow processing intended to utilize the higher layers must occur at some point past one end or the other end of the virtual circuit.

The gateway router **125** also terminates permanent virtual circuits through the cell relay network **129** going to/from the ISP concentrators **131**. The gateway router **125** aggregates traffic between a number of subscribers and each respective ISP. The ISP equipment **131** typically implements a variation of a point-to-point protocol (PPP) specifically adapted to ride over Ethernet, referred to as "PPP over Ethernet" (PPPoE). The virtual circuits to the ISPs, however, do not have sufficient capacity to simultaneously carry all subscriber traffic at the maximum rates of the customers' subscriptions. The MUX **115**, the ATM switch **123**, and the gateway router **125** concentrate and regulate the subscriber traffic going to and from the ISPs, typically on some type of "best efforts" basis.

In a typical Internet access service offering, the most expensive service tier provides 7.1 Mbps for downstream communication and 680 kbps for upstream communication. The next grade of service provides 1.6 Mbps for downstream communication and 90 kbps for upstream communication, whereas the lowest tier of service provides 640 kbps for downstream communication and 90 kbps for upstream communication. The maximum grade of service offered to an individual subscriber depends on the rates for which the subscriber's line can qualify, although the subscriber may opt for a lower rate service since the higher-rate service is more expensive.

The approach outlined above relative to FIGS. **14** and **15** works well for Internet access if the traffic relates to web access, file transfers and the like, which do not require guaranteed quality of service. Various segments of the Internet industry, however, are rapidly developing new multimedia services and applications that already are pushing the capabilities of such a network. For example, increasingly, Internet traffic includes a number of types of communication that require a guaranteed quality of service. Voice telephone communication over IP is extremely sensitive to latency and jitter. The permanent virtual circuits provide an unspecified bit rate (UBR) service and do not guarantee any minimal amount of delay or jitter. Also, because the rates are set by subscription, the service tends to be relatively inflexible. Some services, such as multicasting of broadband information from the Internet into the local access ADN for a large number of concurrent users, can quickly overload one or more nodes or critical links of the network, for example the link **119** between the DSLAM **111** and the ATM switch **123** at the hub **121**.

Most industry experts propose to increase the services available via the public Internet. However, because the higher layer protocols are visible only on the Internet side of the virtual circuit "pipe," these services all must be implemented out past the end of the virtual circuit, at least behind the gateway router **129** and most likely in the public network, where it is possible to view and route based on higher level protocols, particularly Internet protocol (IP). Such a migration strategy to implement new services creates severe problems. For example, in the network of FIG. **14**, if a customer at premises **200**, desired to order a video on demand, the customer would communicate via the assigned permanent virtual circuit and the ISP to a server on the Internet **132**. The server would send the video stream back through the Internet **132**, the ISP equipment **131**, the cell relay network **129** and the virtual circuit from the router **125** to the ATU-R **203** for handoff to a PC or the like at **215**. If the rate of the requested video exceeds the customer's subscription rate, the customer could not view the video in real time during the download. Even if the rate of the requested video is below the customer's subscription rate, loading in the Internet or the local access network may impose delays and/or jitter in communication of some segments of the requested video. Assuming that the hub **121** and the links **119** implement a subscriber concentration, ordering of videos or similar broadband files from the Internet **132** quickly consumes the shared resources through the hub **121** and the links **119**, reducing the rates of service provided to other customers seeking concurrent Internet access.

It might be possible to increase the capacity of the links **119** and/or the hubs **121**; however, this tends to increase the carrier's recurring costs and often makes the overall service (s) of the ADN network economically impractical.

It has also been suggested to provide customers guaranteed quality of services for some portion of their communications, by segregating the traffic carried between the customer premises and the hub **121**. This would require assigning a plurality of ATM permanent virtual circuits to each subscriber, one for each different guaranteed level of quality of service and one for all other Internet traffic for the subscriber. Administration and provisioning of one virtual circuit per subscriber is already complicated, and the number of virtual circuits through any given ATM node is limited by current equipment designs. Expanding the number of permanent virtual circuits per subscriber to support multiple QoS tiers of service therefore would be quite expensive, and the management thereof would become a nightmare. To support an increased number of virtual circuits, many having guaranteed QoS requiring some substantial minimum rate at all times, would also require that the operator substantially upgrade the network to increase the end-to-end capacity all the way to the wide area network **132**.

Furthermore, to actually receive the desired QoS requires that all elements involved in the communication must guarantee the desired level or quality of service. For communications across the public Internet **132**, this means that various nodes and links on the public Internet must be available and capable of providing a guarantee of the desired QoS. In point of fact, few nodes on the public Internet actually support any type of QoS. Hence, even if the ADN supported a desired QoS, most subscribers would not benefit from that service because their communications over the public Internet would have no QoS guarantee, and would suffer from the usual problems of latency and jitter.

Consequently, current deployments of ADSL-based data networks, such as shown in FIGS. **14** and **15** generate many customer complaints. From the customer perspective, the service does not deliver the data rates that the customer pays

for on a consistent basis. The customer typically blames such problems on network equipment failure. In fact, most of the problems already are due to virtual circuit congestion problems, of the kinds outlined above. Essentially, the ADN network is crippled by the unpredictable nature of the service levels that the customers perceive due to congestion on the ADN and on the public Internet.

Also, with this approach, because all of the major service elements are implemented in servers accessible to the Internet, all of the services are subject to severe security risks. Each service provider's server is accessible to virtually any computer coupled for communication via the Internet. This openness is a desirable feature of the public Internet. However, a consequence is that any such server is accessible to and thus subject to attack from any hacker having Internet communications capabilities. Popular services, particularly those generating substantial revenues, become prime targets for attack.

Another area of problems is that the ADN does not offer the carrier any technique for offering its own differentiated service applications. To compete with other service providers, the carrier operating the ADSL-based data network needs to introduce its own multimedia services, for example, its own video services to compete with video services of cable television companies (that offer competing Internet access services). As noted above, however, introduction of a new service, such as true video on demand or broadcast video requires communications via the public Internet **132**. This is true even if the carrier operating the network of FIGS. **14** and **15** wanted to initiate its own video service(s).

Hence, there is an ongoing need to improve the architecture and operation of a digital subscriber line data communication network, particularly to facilitate finer gradation of services within the local network. The need, first, is for such a local network to support introduction of services on a 'vertical' basis within the local access network separate and apart from the common forms of Internet traffic, both for commercial differentiation and for increased security. In a related need, the local network needs to support a number of different levels of quality of service (QoS). There also exists a need for upstream traffic to be shaped by customer equipment located at or near the interface between a customer's network and the ADN according to traffic destinations. A similar need also exists for such customer equipment to prioritize and queue the upstream traffic according to QoS metrics mirroring those of the ADN.

SUMMARY OF THE INVENTION

A general objective of the invention is to implement an enhanced digital communication network for subscriber lines that supports vertical introduction of new communication and/or multimedia services.

A further objective is to support multiple levels or grades of quality of service within the access network.

Another objective of the invention relates to improvement of the cost effectiveness of the data network, for example, by reducing the demand for high-capacity interoffice links while increasing the bandwidth available at the network edge for at least some types of services.

A related objective is to provide a technique for introduction of new high-end services near the network edge, from a domain that is more secure and therefore less subject to hacker attacks.

A further objective of the invention is to support QoS and/or local introduction of vertical services, without the need to assign multiple virtual circuits or the like to each subscriber.

Still further objectives of the invention relate to provisioning of service through an access data network. Specifically, it is an objective of the provisioning related concepts to significantly reduce, or completely remove, the errors present in the existing data circuit provisioning process, which includes: manual ordering processes; manual record-keeping; and manual circuit changes at the PSTN frame and the intermediate ADSL frame.

A further objective of the invention is to support customer premises data equipment that have conventional protocol stacks without the need for additional or proprietary shim software in each user device.

A related objective is to support a plurality of different customer premises data equipment that each include a network stack implementing a common communications protocol.

Another objective of the invention is to provide a single logical communications session which multiplexes multiple actual sessions between a customer data equipment and other devices on a local access network or the Internet. A related objective is multiplexing multiple sessions from various customer premises data equipment over a single logical communications session.

A further objective of the invention is to alter data frames received from customer premises data equipment according to the destination network domain of the payload of that data frame and to forward the altered data frame to the ADN.

Another objective of the invention is to enforce access control lists that prevent certain sessions from being established or used between particular customer premises data equipment and particular network destinations.

A further objective of the invention is to support QoS guarantees in the upstream traffic received from customer premises data equipment and forwarded to the ADN.

The preferred embodiments of the invention alleviate many of the above noted problems by providing an intermediate node, typically an enhanced switch, to segregate upstream traffic based on analysis of the type of communication. This analysis utilizes protocol information contained in each communication, for a protocol higher than the switching protocol, that is to say higher than a protocol used to define the customer's logical circuit. In an implementation utilizing ATM, for example, the logical circuit is a virtual circuit, and the node examines the protocol information for layers above the ATM layer. One type of traffic remains on the virtual circuit, whereas other traffic is handed off to a vertical services domain. The node also provides a point to aggregate traffic from the from the vertical services domain with other traffic on the subscriber's logical circuit, for transport to the customer premises equipment.

To this end, the preferred embodiments use an ATM switch having routing/processing capabilities at the higher layer, for example at the layer-3 protocol or above, in close proximity to a DLSAM. The links between the DSLAM and this switch can be of any desired high capacity because they are short and therefore relatively low in cost. Consequently, the DSLAM and the new ATM switch can support relatively high bandwidth from that node to the customer premises. To utilize the increased bandwidth and support new services, the modems on the opposite ends of the digital subscriber line negotiate and operate at the maximum rate that the line conditions will permit.

The ATM switch essentially subdivides the traffic associated with each subscriber line. One branch goes to a gateway router and hence to one or more ISP(s) at the rate corresponding to the Internet access subscription. It may be

helpful to consider this as long distance or wide area traffic for the subscriber. The other branch is for local traffic, to and from the locally connected vertical services domain. The interconnection to the vertical services domain supports QoS and introduction of vertical services not easily provided from the public Internet, such as video on demand, multicasting, and voice over IP. The vertical services domain is relatively secure since it is not accessible from the public Internet.

In operation, the access network will still support a logical circuit in the form of a virtual circuit to the gateway router for each customer, for example in the form of an ATM permanent virtual circuit. That circuit is provisioned for the subscriber's desired grade or quality of Internet access service. The subscriber line, however, supports at least the same and often a higher rate service, for example via rate-adaptive ADSL communication over a twisted wire line. In the upstream direction, the ATM switch examines at least one aspect of each data transmission relating to a logically higher level of protocol, e.g. in a layer 2 protocol encapsulated in ATM, or at layer 3, layer 4, or higher. From the higher level information, the switch determines the type of transmission and segregates the upstream transmissions on the subscriber's virtual circuit. One type of transmission continues on the virtual circuit, e.g. for Internet transport. Any and all other types, however, go to the vertical services domain. In the downstream direction, the ATM switch aggregates any communications coming from the vertical services domain together with downstream transmissions on the virtual circuit from the Internet.

The vertical services domain also represents a communication network. The vertical services domain, however, preferably takes the form of a data network optimized for local transport of vertically injected services, that is to say local data traffic. In view of its local nature, it is easier and more cost effective to provide high bandwidth services. The vertical services network, for example, could take the form of a giga-bit Ethernet type local area network. Also, it is easier to adapt the vertical services network to support service level agreements with customers with regard to quality of service. In many cases, it actually is sufficient to support QoS on the one hop through the ATM switch, itself.

To support the QoS requirements, a feature of the preferred embodiments involves certain queuing and tagging operations within the ATM switch. Essentially, the switch will maintain two or more queues for each permanent virtual circuit. The switch distinguishes the queues based on importance. As the switch receives cell transmissions for transport over the virtual circuit to the customer premises, the switch will internally tag each cell as to its importance level and place the cell in the appropriate queue. The switch may implement any one of a number of different algorithms to select and transmit cells from the various queues. The particular algorithm is selected to implement QoS in conformance with the subscriber's service level agreement with the carrier and/or agreements between the carrier and the vertical services providers.

Within the one virtual circuit assigned to the individual subscriber, the invention actually provides multiple tiers of service, preferably with multiple levels of QoS. Also, at different sections along the virtual circuit "pipe," the network provides different levels of rate shaping. All layers and all services are available at the home, but different services receive different treatments in the network conforming to the different levels of QoS. The inventive approach, however, does not require each subscriber to have multiple virtual circuits.

Services provided on the vertical services domain appear as IP data services. Virtually any communication service may utilize the vertical services network and through it to gain access to the carrier's local customer base, simply by providing an IP interface for coupling to the vertical services network. For example, it is a simple matter to connect any digital source of broadcast audio or video information, such as a direct satellite broadcast receiver system similar to those used today in residential applications, through an IP interface. Such a broadcast source and interface can provide the full range of received video services, over the vertical services network. The access data network may distribute the video programming to a number of access switches within a local geographic area. The switch provides an optimum point for frame or cell replication for multicasting services. Hence, in our video example, the switch replicates and distributes frames for the broadcast service over the digital subscriber line circuits to customers desiring to view the programming.

An aspect of the present invention relates to a CPE and associated software and methodologies for separating a protocol stack shim software from the customer devices, or customer premises data equipment, using the network services. According to this aspect of the invention, a CPE is provided that receives data from the devices according to a common encapsulation scheme, determines the encapsulation scheme needed in order for that data to be properly routed in the access network, and then encapsulates the data into the appropriate ethertype frame. Typically, Internet-bound frames are encapsulated using PPPoE so they pass through the VSI switch, while frames destined for the vertical services domain are encapsulated using another ethertype to allow the VSI switch to properly route them. A number of benefits arise from locating the PPPoE software on the CPE, including, for example, increased security control, PPPoE proxy services, and implementation of QoS in the upstream direction.

A further aspect of the invention relates to unique software for implementing, for example, the frame examining, destination determining, frame altering, security enforcing, and QoS prioritizing functions of the CPE. A software product, in accord with this aspect, includes at least one machine readable medium and programming code, carried by that medium. In a preferred embodiment, the code includes several cooperating applications which may reside in separate media within the CPE.

A computer readable medium, as used herein, may be any physical element or carrier wave, which can bear instructions or code for performing a sequence of steps in a machine readable form. Examples of physical forms of such media include floppy disks, flexible disks, hard disks, magnetic tape, any other magnetic medium, a CD-ROM, any other optical medium, a RAM, a ROM, a PROM, an EPROM, a FLASH-EPROM, any other memory chip or cartridge, as well as media bearing the software in a scannable format. A carrier wave type of medium is any type of signal that may carry digital information representative of the instructions or code for performing the sequence of steps. Such a carrier wave may be received via a wireline or fiber-optic network, via a modem, or as a radio-frequency or infrared signal, or any other type of signal which a computer or the like may receive and decode.

Additional objects, advantages and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following and the accompanying drawings or may be learned by practice of the

invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing figures depict preferred embodiments of the present invention by way of example, not by way of limitations. In the figures, like reference numerals refer to the same or similar elements.

FIG. **1** is a functional block diagram of a digital subscriber line data network supporting enhanced services in accord with the inventive concepts.

FIG. **2** is a slightly modified functional block diagram of network of FIG. **1**, illustrating the protocol stacks used in the various network elements.

FIG. **3** is a functional block diagram of the network showing the service level agreements (SLAs) for which the network provides appropriate QoS.

FIG. **4** is a logical diagram of the functional elements of an L3/4 switch, for use in the inventive network of FIGS. **1–3**.

FIG. **5** is a block diagram of a modified portion of the network, useful in explaining migration to other types of physical transport and switching/routing protocols.

FIG. **6** is a block diagram of a portion of the network of FIG. **5**, showing the interconnection thereof with the wide area network and the local vertical services domain.

FIG. **7** is a block diagram of the network similar to those of FIGS. **1** and **2**, but showing details with regard to certain elements thereof enabling an automated service selection and provisioning procedure in accord with a further aspect of the invention.

FIG. **8** is a flow-chart illustrating the steps of an example of the automated service selection and provisioning procedure.

FIG. **9** is a simplified diagram of the network of FIGS. **1** and **2** but showing customer premises equipment (CPE) according to an alternative embodiment of the present invention.

FIGS. **10** and **11** illustrate a detailed schematic and logical view, respectively, of the features within the CPE of FIG. **9**.

FIG. **12** is a flow-chart illustrating the steps of an example of the CPE encapsulating frames according to the intended network destination of the frame.

FIG. **13** is a flowchart illustrating the steps of an example of automatically programming the CPE according to the services used by a customer.

FIG. **14** a block diagram of a prior art asymmetrical digital subscriber line data network.

FIG. **15** is a slightly modified functional block diagram of the prior art network illustrating the protocol stacks used in the various network elements.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

The inventive network architecture introduces QoS into the ADN, in a manner that enables the delivery of sophisticated and demanding IP-based services to subscribers. The architecture does not affect existing Internet tiers of service such that the promised rates for such access appear the same as offered today. Also, the new architecture is cost-effective in terms of initial costs, build-out, and ongoing operations. The architecture utilizes an access switch or router capable of examining and selectively forwarding packets based on a relatively higher layer of the protocol stack, that is to say based on information encapsulated within the layer-2 information utilized as the lowest level definition of connectivity through the network. The access switch enables segregation of upstream traffic by communication type and downstream aggregation of wide area traffic together with traffic from a local vertical services domain.

In accord with the invention, the access switch examines the higher-level protocol information in the upstream communications to segregate traffic into two or more streams based on traffic type. A logical circuit provisioned for the subscriber extends from the customer premises through the switch to a node providing service to the packet switched network, typically on the Internet. The provisioning of this circuit defines a contiguous connectivity for the logical circuit, in the layer-2 protocol utilized by the network. Higher level protocols ride within this particular layer-2 protocol, including some protocols that are often considered themselves to be layer-2 protocols.

The analysis of upstream packets to determine higher-level type enables segregation of the upstream traffic into two or more upstream flows. For example, this allows the switch in the preferred embodiment to keep traffic bound for the packet switched internetwork on the logical circuit but route all other traffic onto another network, in this case a local network for vertical services. In the preferred embodiment, from the access switch or router to the packet switched network, the provisioning for the logical circuit limits the rate(s) of communication to those defined by the grade of service to which the customer subscribes. From the customer premises to the switch, however, the communications run at the optimum rates that the facilities can physically support, e.g. the maximum rates that the ADSL modems or the like can adaptively establish for the particular subscriber's line.

In the downstream direction, the switch aggregates traffic for each subscriber. The switch receives the rate-limited traffic from the packet switched network, on the subscriber's logical circuit. The switch also receives any downstream traffic intended for the subscriber, from the vertical services network. The switch combines this traffic and sends the combined communications downstream over the subscriber's logical circuit to the customer premises, at the optimum downstream rate that the subscriber's facilities can support.

The functionality of the customer premises data equipment that formats upstream frames according to a frame's destination within the ADN can be performed by a separate device positioned between the customer premises data equipment and the ADN. The term "separate device" simply means the device is distinct from the customer premises data equipment; however, this device could be a physical part of some other device, for example, the ATU-R. This separate device can segregate traffic into different data types, according to destinations within the ADN, with the upstream switch or router still performing forwarding of the traffic according to its type. This separate device can act as a session proxy and also enforce other traffic rule-sets such as security access control lists and QoS metrics that mirror those of the ADN.

FIG. **1** provides a high-level functional illustration of an exemplary digital subscriber line network, specifically an ADSL data network **10**, implementing the various concepts of the present invention. FIG. **2** provides an alternative functional illustration of the elements of such a network. Of particular note, FIG. **2** shows the various protocol stacks

associated with the appropriate network elements that utilize those stacks. The end-user may be a single PC user or a small business or a residential LAN user. The data equipment of such users typically includes servers and PCs and may include a variety of other devices, such as fax machines, televisions, recorders and remote controlled appliances, having data communication capabilities.

The customer access link comprises an xDSL twisted pair, although those skilled in the art will recognize that the invention is readily adaptable to networks using other types of links to the subscriber premises. In the illustrated embodiment, the network **10** supports ADSL, which the carrier may offer in grades supporting 640 kbps, 1.6 Mbps or 7.1 Mbps (downstream) rates for Internet access. The actual communications over the DSL loops, however, run adaptively at the maximum rates that the line conditions allow.

The ADSL-based local access data network or "ADN" **10** provides access to two different network domains for communication services. The two network domains are logically separate. In most implementations, the first domain may be considered as a long distance or wide area domain, whereas the second domain is a local network domain. In the illustrated example, the ADN **10** provides access to a first domain in the form of a wide area internetwork, such as the public Internet, corporate local area networks (LANs), and the like, represented by the network cloud **11** for the ISPs. The high speeds available through the local network **10** enable a wide range of communications, for example, of text data, of video data, for multimedia, for web browsing, of transfers of files, for database searching, and the like via the network(s) **11**.

In accord with the invention, the ADSL-based local access network **10** also offers access to a wide variety of other IP-based services through a local data network **13** serving as the vertical services domain (VSD). The vertical services typically are high-end services requiring certain QoS levels and often having a certain local characteristic. Examples of the vertical services are discussed in more detail later.

The vertical services network offers an efficient domain from which the carrier can locally inject high-end services and/or services of other local providers. Because the vertical services domain is separate from the public Internet, equipment providing the vertical services is subject to attacks directly from the public Internet.

As shown in FIGS. **1** and **2**, a central office (CO) **15** comprises one or more DSLAMs **17** and L3/4 ATM switch **19**. Elements of the CO **15** providing plain old telephone service (POTS) have been omitted for simplicity of illustration, since they are generally similar to those shown in FIG. **9**.

The switch **19** is designated as an "L3/4" switch here as a matter of convenience, to illustrate that the switch **19** has the capability to make selective packet forwarding decisions based on protocol information at some level that is above the L2 level that the switch normally utilizes to define or establish logical circuit connectivity. It will be recognized, however, that some of the protocols, although higher than the ATM type level 2 protocol used by the preferred switch are themselves often thought of as level 2 protocols even though they are above or encapsulated in the ATM type level 2 information. Also, decisions as to the selective forwarding may be made in response to monitoring of any level of the protocol stack above the L2 level that the switch normally utilizes to define or establish logical circuit connectivity, for example from any level above ATM all the way up to the L7 application layer.

Returning to the discussion of FIGS. **1** and **2**, for purposes of this discussion, assume that the equipment at the various customer premises connect directly to the CO **15** via twisted pair type copper wiring **21**. In an actual implementation, many customers may connect through such wiring to a remote terminal linked to the CO **15** via optical fiber. Other hardwired, optical or wireless implementations of the digital subscriber lines are discussed later. In the illustrated embodiment, each line **21** from a customer premises connects to an ATU-C within one of the DSLAMs **17**.

On the customer premises side, the digital subscriber line circuit **21** connects to an ADSL terminal unit (remote) or ATU-R **23**. The ATU-R **23** is a modulator/demodulator (modem) for communicating over a twisted wire pair type line **21**, in accord with the ADSL protocols. The ATU-R in turn connects to customer premises equipment, shown by way of example as a PC **25** at each location (FIGS. **1** and **2**). Those skilled in the art will recognize that the customer premises equipment **25** may include a wide range of other types of devices having data communications capabilities (see e.g., FIG. **3**).

The ADSL user's normal telephone equipment (not shown) also connects to the line **21**, either directly or through a frequency combiner/splitter, which often is incorporated in the ATU-R. The normal telephone signals are split off at both ends of the line and processed in the normal manner.

For digital data communication purposes, the ATU-C and ATU-R modem units create at least two logical channels in the frequency spectrum above that used for the normal telephone traffic. One of these channels is a medium speed duplex channel; the other is a high-speed downstream only channel. Such modems may implement either one of two techniques for dividing the usable bandwidth of the telephone line to provide these channels. One approach is to divide the usable bandwidth of a twisted wire pair telephone line by frequency, that is to say by Frequency Division Multiplexing (FDM). The other approach uses Echo Cancellation. FDM uses one frequency band for upstream data and another frequency band for downstream data. The downstream path is then divided by time division multiplexing signals into one or more high-speed channels and one or more low speed channels. The upstream path also may be time-division multiplexed into corresponding low speed channels. With echo Cancellation, the upstream band and downstream band substantially over-lap. The modems separate the upstream and downstream signals by means of local echo cancellors, in a manner similar to that used in V.32 and V.34 modems.

The DSL modems may use a number of different modulation techniques to physically transport digital data streams. A number of implementations of the modems have used carrierless amplitude phase (CAP) modulation. Most current xDSL modems, however, utilize a discrete multi-tone (DMT) approach.

Returning to the discussion of the CO **11**, the structure and operation of each DSLAM **17** is essentially the same as those of the DSLAM **111** in the embodiment of FIG. **9**, except that the control functionality of the DSLAM **17** is somewhat different. The DSLAM **17** controls the ATU-Cs to implement a rate-adaptive ADSL service, to adapt operations so as to maximize data rates for the communications over the individual subscriber lines. Essentially, the ATU-Cs and ATU-Rs signal each other over the lines to synchronize

their modes of operation at parameter settings, which achieve optimum data throughput. Also, the DSLAM **17** does not need to monitor or limit the line rates, but instead relies on the rate-adaptive control algorithm to maximize the rates achieved over the ADSL circuits or provide rate-shaping for the ATM virtual circuits. Other network elements limit rates, where necessary.

The L3/4 ATM switch **19** is co-located with the DSLAMs **17**, within one central office **15**. As a result, it is practical to connect the multiplexer within each of the DSLAMs **17** over a high-speed data link directly to an appropriate port of the ATM switch **19**. Because these links are short, there is little or no cost imposed when implementing such links using wideband equipment. By itself, the co-location of the L3/4 ATM switch **19** with the DSLAM(s) **17** does not increase bandwidth. Rather, it makes increased bandwidth at the network edge economically feasible, due to proximity. Co-location removes the requirement to purchase expensive wide area transport (the SONET ring) to increase bandwidth. In particular, the direct OC3/OC12 connections between the DSLAM **17** and the L3/4 ATM switch **19** do not incur any recurring tariff expenses.

The ATM switch **19** connects through a SONET ring **27** to a gateway router **29** providing ATM transport through a cell relay network **30** (FIG. **2**) to the ISPs shown at network **11** in the drawings. Most of the ISPs will utilize a concentrator or other equipment as their point of presence for Internet access (FIG. **2**). In the preferred embodiment, the equipment **31** provides a point-to-point protocol (PPP) interface designed for transport over Ethernet (PPPoE). The ATM switch **19** also provides a connection to the local implementation of the VSD network **13**, for example via a giga-bit Ethernet port to a switch or other local network elements **18**.

The illustrated local access type ADN network **10** provides ATM cell transport from the customer premises to the ISP network(s) **11**. The ATM cells serve as the layer-2 protocol for defining contiguous switched connectivity. Higher level routing protocols, such as Ethernet and TCP/IP frames, ride within the ATM cells. Services of different types utilize different protocols at one or more layers above the ATM cell layer. In the preferred embodiments, all communications utilize Ethernet. However, communications to and from the ISPs use the noted PPPoE type Ethernet protocol. In contrast, communications to and from the vertical services domain use one or more of the other Ethertype protocols.

To efficiently provide cell relay, each customer is assigned a virtual circuit that extends from the ATU-R **23** in the respective customer premises to the gateway router **29**. This logical circuit is defined at the layer-2 protocol level. The present implementations implement this logical communication circuit as an ATM permanent virtual circuit, although the inventive concepts may apply to other types of logical circuits or channels.

The gateway router **29** is the communication node of the access network **10** providing access to the wide area IP packet networks, of corporations or more often of Internet Service providers. The gateway router **29** terminates permanent virtual circuits through the cell relay network **30**, from the equipment **31** of each such wide area packet network provider **11**. The gateway router **29** also terminates the permanent virtual circuits from the subscribers through the data network **10**. For communication with a selected ISP network **11**, for example, the gateway router **29** routes cells from the permanent virtual circuit from the subscriber through to the permanent virtual circuit of the selected ISP network **11**. In the opposite direction, the gateway router **29** routes cells from the permanent virtual circuit from the selected ISP network **11** through to the permanent virtual circuit of the particular subscriber.

For the leg of the subscriber's logical circuit, extending from the L3/4 ATM switch **19** through the gateway router **29**, the carrier programs one or more nodes along the path behind the DSLAMs **17**, to regulate traffic on the virtual circuit to the rate corresponding to the grade of Internet access service to which the particular customer subscribes. In the preferred embodiment, at least one such node performing this rate shaping function is the L3/4 ATM switch **19**. All traffic going to and from the ISP network(s) **11** therefore is still limited to the rates defined in the service level agreement (SLA) for Internet access that the carrier has with the particular customer.

The portion of the virtual circuit extending between the ATM switch **19** and the ATU-R **23**, however, is not rate limited but instead runs at the maximum rate that the line will support using the rate-adaptive ADSL modem operation. In most cases, the rate-adaptive ADSL modem operation will support rates substantially higher than the subscription rate for Internet access service.

The L3/4 ATM switch **19** also provides the interconnection to the subscriber's virtual circuit for insertion of downstream traffic from the vertical services domain **13** and separation of upstream traffic from the subscriber's virtual circuit going to the vertical services domain **13**. In accord with the invention, decisions as to whether upstream traffic is destined for the vertical services domain **13** or should remain on the subscriber's virtual circuit going through the gateway router **29** and the cell relay network **30** to the ISPs **11** is based on an analysis of traffic type. The traffic type analysis relies on protocol information contained in the communications, which relates to layers of the protocol stack that are higher than the layer-2 switching protocol, in this case above the ATM layer.

As shown in FIG. **2**, traffic destined for an ISP **11** utilizes a variation of a point to point protocol (PPP) intended to run on top of Ethernet, referred to as PPP over Ethernet or "PPPoE." A 'type' indicator contained within the Ethernet frames identifies the PPPoE protocol. In contrast, traffic going to and from the vertical services domain utilizes other 'types' of Ethernet protocol. All traffic to and from the customer premises uses Ethernet frames carried within ATM cells.

The switch **19** therefore routes a subscriber's traffic going to and from an ISP **11**, upon detection of the PPPoE indicator in the level 3 data contained within the Ethernet cells. This traffic will also utilize public IP addressing. In contrast, the ATM switch **19** routes a subscriber's traffic going to and from the vertical services domain, upon detection of any other type of Ethernet protocol at level 3 or above in the protocol stack. The IP addressing in the vertical services domain **13** utilizes private-IP addresses, for example, as administered with a DHCP server (not shown) coupled to the network cloud **33**. Although shown separately, the cloud **33** may be implemented as a portion of the network providing the physical elements of the vertical services domain. The portion **33**, however, would typically be a logically separate domain that the carrier controls and restricts for its own network administration use.

FIG. **3** depicts the logical division of the subscriber's traffic, as implemented at the ATM switch **19** in accord with the invention. As shown, the network **10** provides a logical "pipe" or circuit **35** extending to the networks **11** of one or

more of the ISPs, for an Internet access application. The ATM switch **19** (FIG. 1) preferably performs a rate shaping or control function. The leg **35** of the subscriber's traffic extending to the ISP **11** provides upstream and downstream communication rates conforming to a service level agreement (SLA) applicable to the subscriber's Internet access application. As such, the communications over the subscriber's logical circuit, extending from the switch to the ISP, provide a first level of QoS. To the subscriber, service over the leg **35** appears the same as a subscriber selected grade of Internet access service as provided by older ADN architectures. FIG. **3** illustrates chat rooms, web surfing and e-mail as examples of services an ISP might offer through the Internet Application SLA circuit **35** and the attendant portion of the subscriber's assigned logical circuit through the access network.

The network **10** also supports communications over one or more logical application paths **36** to local applications **37** hosted in the vertical services domain. Assuming that a subscriber with various equipment **25** also subscribes or otherwise participates in one or more of the vertical services, the local carrier (e.g. Bell Atlantic in FIG. **3**) offers a corresponding number of additional application SLAs with the customer. Each SLA for a vertical service may specify QoS parameters for the particular application, such as rate/bandwidth, latency, jitter, packet loss, packet sequence, security and/or availability. Examples of such applications hosted in the carrier's vertical services domain **37** include the illustrated voice over IP service shown as a V/IP gateway, as well as video services and some caching for high volume local web services. Communications for such applications utilize the one or more paths **36**.

The network of FIGS. **1** to **3** also supports closed or private user work groups or virtual local area networks (VLANs). VLANs, for example, may be implemented as a service hosted through the vertical services network **13**. All traffic from customer premises belonging to one of the VLANs would include a VLAN Ethertype indicator. Since the frames would not be PPPoE type Ethernet frames, the switch **19** would route the upstream transmission to the vertical services network **13**. VLAN frames also carry a VLAN identifier. The nodes of the network **13** transport the packets for the VLAN members only to resources that are members of the identified VLAN. In this manner, the capability exists for creating logical workgroups of users and their shared resources (servers, printers, etc.), that may be physically separated from each other. VLAN groupings can provide privacy and security to their members while enabling "broadcast domains" whereby broadcast traffic is kept logically "inside" the VLAN.

The present invention also supports segregation and aggregation of traffic for three or more domains, based on the higher-level traffic type analysis. An alternative implementation for closed user group services therefore might actually provide a third domain for such services. PPPoE traffic would go to the concentrator equipment **31**, as discussed above. The switch **19** would route the upstream transmission frames bearing a VLAN Ethertype indicator to the alternate network serving as the VLAN service domain. That domain would process VLAN communications essentially as done in a normal switched Ethernet type network. Upstream transmissions that bear any other type of Ethertype indicator would go to the vertical services network **13**, as in the earlier examples.

A feature of the switch, in accord with the invention, is that it prioritizes traffic for each customer to support QoS for the various services as required by service level agreements (SLAs) between the customer and the carrier. In this regard, one implementation of the L3/4 ATM switch **19** performs queuing and tagging operations in accord with the desired prioritization. The switch will maintain two or more queues for each subscriber's permanent virtual circuit. The switch distinguishes the queues based on importance or priority. As the switch receives cell transmissions for transport over the virtual circuit to the customer premises, the switch will internally tag each cell as to its importance level and place each cell in the appropriate queue based on the tag.

The tagging and prioritization may be based on traffic type or 'Type of Service' (ToS). Table 1 illustrates one example of the possible ToS levels that may be assigned to different communications.

TABLE 1

Relative Priority	ToS Value	AR Queuing	Customer Traffic Encapsulated TOS	Internal BA Mgmt Traffic Rewritten TOS
Critical Management	0	WFQ (Control 25%)		OSPF, SNMP, ICMP, BGP
Future	1			
Real Time Interactive	2	WFQ (High 40%)	Port numbers identified	
IP Application Control	3	WFQ (Medium 30%)	ICMP, IGMP, EGP, DNS, H.323 signaling, BGP, SIP, Microsoft Media Player Streaming Media Control, RTSP	IGMP, RADIUS
One Way Streaming Media	4		UDP (ports 1024+)	
One Way Batch	5		HTTP, HTTPS, SNMP, Telnet	
Unknown	6	WFQ (Low 5%)	Other	Other
Non time sensitive	7		FTP, TFTP, SMTP	

The access switch **19** will examine the content of each communication and determine an appropriate ToS level, for example in accord with the table above. Based on the ToS level, the switch will add a tag to the cell(s) as part of its internal processing. Using the ToS tags, the switch will place each of the cells for a given subscriber into a corresponding one of a plurality of queues that the switch maintains for the subscriber's traffic.

The switch may implement any one of a number of different queue servicing algorithms to select and transmit cells from the various queues. For example, the switch **19** may implement one of several statistical algorithms, equal queuing, weighted queuing, priority selection from queues, etc. The particular algorithm is selected to implement QoS in conformance with the subscriber's service level agreements (SLAs) with the carrier. In most cases, particularly for service applications from the vertical services domain, the switch **19** will not normally drop any cells or packets. In the rare event that the switch **19** becomes congested, any dropping of cells is based on the priority level assigned to the frame, i.e., lowest priority first. Also, if the switch ever drops cells, it drops all cells for an effected lowest priority frame from the relevant queue.

The ability to prioritize traffic across the inserted streams and the PPPoE stream enables the operator to control flows through the ADN **10** so that the local access facility is not overwhelmed with content which exceeds its physical (rate adaptive) limitations. For example, the queuing rules preferably ensure that the 'proper' applications (based on insertion device based rules) obtain access to the limited rate adaptive bandwidth available on any given subscriber's line. Also, the insertion point, switch **19**, will usually sit behind the media conversion point (e.g., the DSLAM **17**). An OC3 or other facility between the switch **19** and the DSLAM **17** also could become congested. Preferably, the switch **19** or other element at the insertion point queues the traffic in such a manner that no downstream facility (OC3) limitations (which are independent of the rate adaptive DSL loop limitations) will result in packets being dropped.

The queuing will be done based on customer and network provider determined rules so that contention for the facilities facing the subscriber will be addressed via the dropping of the appropriate packets. That way an inserted video stream doesn't overwhelm a PPPoE or Voice stream (due to facility limitations). Among others, appropriate industry understood methods for accomplishing this queuing control include Weighted Fair Queuing (WFQ), Priority (PQ) Queuing, and Weighted Random Early Discard (WRED).

Also, the ability of the switch **19** to examine higher level information provides other advantages in network operations. For example, the switch can implement sophisticated filters on the higher level information, e.g., to provide security. As another example, the switch preferably performs measuring and monitoring to determine what if any packets get dropped (based on the physical rate adaptive limitations), and generates appropriate reports to an external operations system (not shown).

The introduction of the L3/4 ATM switch **19** in proximity to the DSLAM(s) **17** also provides benefits in terms of operation of the gateway router **29**. Due to the end-to-end use of the Unspecified Bit Rate (UBR) PVCs, the gateway router interface to the cell relay network **30** has been engineered to support a maximum of 2000–4000 PVCs (end users). This is essentially an over-provisioning of bandwidth that probabilistically avoids service degradation that could result from simultaneous demand for bandwidth. The ability of the L3/4 ATM switch **19** to perform QoS and rate shaping essentially reduces or ever removes this concern, because it significantly reduces the risk that the gateway router **29** will become a bottleneck. As a result, the ADN **10** can increase bandwidth efficiencies for this interface. Further, the capacity through the gateway router **29** need not be upgraded as often to support demand for increased bandwidth associated with new bandwidth-intensive services, since many such services are now introduced through the vertical services domain **13** and the L3/4 ATM switch **19**.

To fully understand an exemplary implementation of the various inventive concepts, it may be helpful to consider an ATM-based embodiment of the L3/4 switch **19**. FIG. **4** is a block diagram of the elements and functions of such a preferred embodiment of the switch **19**.

The preferred embodiments utilize Ethernet framing. As shown in the drawing, the switch **19** includes an Ethernet interface **41**, an ATM interface **42** and an associated physical interface **43** facing toward the subscribers. In an embodiment for use in the network of FIGS. **1** and **2**, the physical interface might take the form of one or more OC-3 or OC-12 links to the DSLAMs **17**. These links carry all ATM cell traffic going to and from the DSLAMs and hence to and from the customer equipment served through the particular switch **19**.

The switch **19** also includes an Ethernet interface **44**, an ATM interface **45** and associated physical interface **46** facing toward the gateway router **29** and hence the ISPs **11**. The physical interface **46** might take the form of one or more OC-12 or OC-48 links to the gateway router **29**. These links carry all ATM cell traffic going to and from the ISPs or other wide area inter-networks **11**. For these communications, the Ethernet interface **44** passes through PPPoE traffic, as specified by the Ethertype indicator in the cells transporting the relevant frame segments.

Facing the vertical services domain, the switch **19** includes an Ethernet interface **47** and a physical interface **48**. These interfaces conform to the particular network utilized by the carrier for the vertical services domain, such as giga-bit Ethernet over wire or optical links.

The switch fabric **49** performs the physical switching of data along various paths through the switch **19**, in response to instructions from a programmed routing controller **50**. FIG. **4** also shows the communications flow through the switch, for each subscriber. The switch **19** also implements a Decision Point **51**, shown for example within the Ethernet interface processing **41** on the subscriber facing side. At that point, the PPPoE traffic is separated from all other traffic. From that point, the PPPoE Flow **52** for each subscriber extends as a portion of the subscriber's ATM virtual circuit, facing the cell relay network and hence the ISPs **11**. The PPPoE Flow **52** contains Ethernet frames that are of PPPoE Ethertype. Facing towards the subscriber premises, the switch **19** implements an Aggregate Flow path **53**, in the form of another portion of the ATM virtual circuit, which contains all ingress/egress subscriber traffic. The switch implements a Generic Path **54** extending through the interfaces to the vertical services network. This path **54** carries all traffic other than PPPoE.

In this example, the switch **19** implements the Decision Point **51** based on recognition of the Ethertype indicator, which is above the layer-2 ATM cell routing information. However, the switch may implement the Decision Point **51** based on still higher-level protocol information. Also, those skilled in the art will recognize that the concepts of the present invention are applicable in networks using different protocol stacks, for example, based on native IP.

In a preferred embodiment, the Ethernet and ATM interfaces **41** and **42** and the Ethernet and ATM interfaces **44** and **45** implement segmentation and reassemble (SAR) functions, essentially providing two-way conversions between ATM cell format and Ethernet frame format. Segmentation involves dividing an Ethernet frame into a number of 48-byte blocks and adding ATM headers to the blocks to form a corresponding number of ATM cells. Any blocks that do not include a complete 48-byte payload are padded

as necessary. Reassembly entails receiving and buffering ATM cells until it is recognized that a complete frame has been received. The ATM headers of the cells and any padding are stripped, and the payload data is reassembled into the form of an Ethernet frame.

In such an embodiment of the switch **19**, the decision point **51** determines how to selectively forward the Ethernet frame information taken from a particular series of upstream ATM cells based on the Ethernet information taken from the ATM cell payloads, for example, by examining the frame header and recognizing the particular Ethertype indicator. Internally, the actual switch fabric **49** for such an embodiment of the switch **19** would comprise an Ethernet switch, even though to other elements of the ADN network **10** the switch **19** appears to perform an ATM switching function.

Those skilled in the art will recognize however, that the decision and switch fabric may be implemented in other ways. For example, a series of cells corresponding to an Ethernet frame could be buffered and the payloads examined just to recognize and identify the Ethertype indicator, without a complete reassemble of the Ethernet frame. This later implementation therefore could utilize an ATM cell-based switch fabric.

From the discussion above, it should already be apparent that certain aspects of the invention relate to setting up logical communication circuits at a relatively low protocol layer corresponding to switching or routing functions and then segregating traffic by distinguishing communication type using higher level protocol information. To insure full understanding on these points, it may be helpful to consider the protocol layer definitions, with particular reference to the illustration of the preferred layers in FIG. **2**. The International Standards Organization (ISO) Open Systems Interconnection (OSI) reference model specifies a hierarchy of protocol layers and defines the function of each layer in the network.

The lowest layer defined by the OSI model is the physical layer (L1). This layer provides transmission of raw data bits over the physical communication channel through the particular network. For example, on the subscriber lines in the preferred embodiment, the physical layer (L1) uses ADSL. Within the customer premises, communications use an Ethernet physical layer (L1), such as 10Base-T. Upstream network elements may use DS3 at some points, but most use SONET, for example OC-3 or OC-12 physical layer transport. Attention is directed to the lower half of the diagram in FIG. **2**, which depicts the various protocol stacks throughout the network **10**.

The layer defined by the OSI model next to the physical layer is the data link layer (L2). The data link layer transforms the physical layer, which interfaces directly with the channel medium, into a communication link that appears error-free to the next layer above, known as the network layer (L3). The data link layer performs such functions as structuring data into packets or frames, and attaching control information to the packets or frames, such as checksums for error detection, and packet numbers. In the network **10**, the data link layer (L2) is used to define certain switching functions through the network. The network layer (L3) provides capabilities required to control connections between end systems through the network, e.g., set-up and tear-down of connections.

The preferred embodiments utilize ATM cell transport as the lowest element of the data link layer (L2), for example to define the connectivity extending from the ATU-Rs **23** through the ADN network **10** to the ISP or corporate networks **11**. Subscriber virtual circuits are provisioned at the ATM cell layer, that is to say at the data link layer (L2). Similarly ISP virtual circuits are provisioned at this ATM data link layer (L2), from the gateway router **29** through the cell relay network **30** to the ISP access concentrators **31**. The ATM protocol therefore is the layer-2 (L2) protocol used to define the logical connectivity from the subscriber premises to the gateway router **29**. The ATM protocol also is the layer-2 (L2) protocol used to define the logical connectivity from the gateway router **29** to the ISP concentrators **31**.

For purposes of this discussion, higher level protocols are protocols that ride on or are encapsulated within the particular layer-2 protocol, that is to say in the payloads of the ATM cells in the preferred embodiment. Such higher level protocols include some protocols, which are often considered themselves to be level-2 protocols, where they are transported within ATM cells. The preferred embodiments use Ethernet, a local area network protocol above the ATM portion of the L2 layer. Technically, the Ethernet protocol may be considered as another L2 layer protocol. However, because it is segmented and encapsulated into the payloads of the ATM cells, the Ethernet protocol information actually is a higher level protocol information above the specific level-2 protocol (ATM) that defines the normal connectivity through the ADN network **10**.

In the OSI model, a transport layer protocol (L4) runs above the network layer. The transport layer provides control of data transfer between end systems. Above the transport layer, a session layer (L5) is responsible for establishing and managing communication between presentation entities. For example, the session layer determines which entity communicates at a given time and establishes any necessary synchronization between the entities. Above the session layer, a presentation layer (L6) serves to represent information transferred between applications in a manner that preserves its meaning (semantics) while resolving differences in the actual representation (syntax). A protocol (L7) that is specific to the actual application that utilizes the information communicated runs at the top of the protocol stack.

In accord with one inventive concept, the network **10** actually utilizes two or more different types of protocol at levels above the protocol within the L2 layer that actually defines the network connectivity. The ADN network **10** may use different protocols at the higher layers as well. By distinguishing transmissions based on differences in these higher-level protocol types, the ATM switch **19** separately forwards different types of communication traffic for each subscriber. In the preferred embodiment, communications to and from the ISP or corporate networks **11** utilize point-to-point protocol (PPP) as the network layer (L3) protocol and a shim for transport of PPP over Ethernet (PPPoE). PPPoE, as one Ethertype protocol could also be considered as a second layer (L2) protocol albeit above the Ethernet layer itself, which in turn rides on the ATM cells used for routing at least through the permanent virtual circuit at the L2 layer.

In the illustrated implementation, however, the use of the PPPoE or a different protocol actually is an indication of a difference in type of the higher layer protocols. In the illustrated example of FIG. **2**, the vertical services domain traffic utilizes Ethernet (802.3 SNAP) above the ATM adaptation layer (AAL). As noted, the presently preferred L3/4 switch **19** implements its routing decision based on recognition of the Ethertype indicator, that is to say to distinguish the PPPoE traffic from all other types of transmission from the customers' data equipment. In view of the use of ATM as the data link layer (L2) protocol of the network defining the lowest layer of network connectivity for communica-

tions services through the ADN network **10**, the discrimination based on Ethernet actually implements a decision based on an effectively higher protocol layer.

IP protocol carries the actual higher-level applications information, for transport to and from the vertical services domain and for transport to and from the wide area internetwork. As such, IP and its related transport protocol referred to as the "Transmission Control Protocol" (TCP) ride on top of (are actually encapsulated within) the lower level protocol elements discussed above. Presentation and application layer elements ride on top of the IP layer. IP communication requires that each user device have an assigned IP address. IP addresses, however, are a scarce commodity. Because of the use of IP transport for both wide area services and vertical domain services, the network **10** actually may at times assign two different IP addresses to each active data communication device of an end-user, albeit on a temporary basis. The wide area communications and the vertical services network may also be viewed as two separate 'broadcast' domains.

First, the carrier operating the ADSL data network **10** and the vertical services domain network **13** will maintain a pool of local addresses for assignment, on an as-needed basis, to end user equipment **25**. To the carrier, the available IP addresses are a limited resource. Accordingly, the carrier assigns IP addresses on a dynamic basis, only to those users actually on-line at any given time. The carrier preferably utilizes private network type IP addresses and dynamically administers such addresses using dynamic host configuration protocol (DHCP). DHCP is a protocol for automatic TCP/IP configuration, which enables dynamic address allocation and management.

When a particular device **25** becomes active via the ATU-R **23** and the DSLAM **17**, it will activate a basic protocol stack, including an IP portion enabling communication with a DHCP server. The device will transmit an address request upstream through the network on the subscriber's virtual circuit. At the Ethernet level, this transmission appears as a broadcast message. The L3/4 ATM switch **19**, however, will recognize that the packet is not a PPPoE communication and route the cells carrying the packet into the vertical services domain **13**. Typically, a DHCP server is coupled to the vertical services domain network **13**, for example as part of the carrier's administrative network or systems **33**. The DHCP server somewhere on the vertical services domain **13, 33** will answer that broadcast request by selecting and providing an available one of the private IP addresses from the carrier's pool of available addresses. The message with the assigned address will go back to the L3/4 ATM switch **19** for insertion into the virtual circuit and transport back to the requesting device **25**.

The particular end-user's device **25** uses the assigned private IP address as its source address, for all of its communications with the vertical services network **13**, so long as it remains on-line for the present session. When the overall session ends and the end-user device **25** goes completely off-line, the DHCP server returns the private IP address to its pool of available addresses, for reassignment to another user as the next user comes on-line.

As noted, the user equipment **25** receives a private IP address from the DHCP server. The addresses of services on the vertical services domain also are private IP networks. Because these addresses are private, they are accessible only to equipment within that domain and the data network **10**. Consequently, the devices are not accessible to hackers or the like coming in through the public Internet.

This dynamic assignment of IP addresses allows the carrier to limit the number of IP addresses used to the number of users actively connected through the ISP's host to the Internet. The use of private IP addresses allows the user equipment to communicate with the vertical services domain utilizing a normal IP-Ethernet protocol stack.

For the as-desired Internet access service, for example using a PPP or similar protocol, IP addresses are administered through the ISPs. The PPPoE protocol preserves or emulates the traditional dial-up approach to ISP access. However, the PPPoE approach does utilize Ethernet and follows Ethernet standards, for example, involving processing of certain broadcast messages.

The user can select an ISP of choice, and her data equipment **25** will initiate a selective session through the Ethernet layer on the network **10** to access the equipment **31** of the selected ISP network **11**, in a manner directly analogous to a dial-up modem call through an ordinary telephone network. Hence at a time after initial activation through the networks **10** and **13**, the user may activate a browser or other program for using the wide area internetwork service. This activates a second protocol stack, which includes the PPP protocol and the PPPoE shim. The user selects an ISP, and the data equipment initiates communication through the network **10** to the PPPoE equipment **31** of that ISP.

The IP addresses used by each ISP are public network type IP addresses. To the ISP, the pool of available public IP addresses also is a limited resource. Accordingly, each ISP prefers to assign IP addresses on a dynamic basis, only to those users actually on-line at any given time. Typically, as part of each initial access operation for a PPPoE session, the user's equipment **25** and the PPP terminating equipment **31** of the ISP conduct a handshaking, to establish data communications therebetween. As part of this operation, the user's device transmits a broadcast request for a public IP network. The broadcast message, in PPPoE goes through the virtual circuit to the gateway router **29** and through the router and cell relay network **30** to the ISPs PPPoE equipment **31**. Although it is a broadcast message, the network effectively limits transport thereof to the virtual circuit going to the ISPs PPPoE equipment **31**, that is to a domain separate from the vertical services network domain **13**.

The ISP host equipment **31** initiates a procedure to assign the user's computer **25** a numeric Internet Protocol (IP) address from the pool of available public addresses and sends a PPPoE message containing that address back to the subscriber's device **25**. When the session ends and the user goes off-line, the ISP host can reassign the address to another user, as the next user comes on-line.

This dynamic assignment of IP addresses allows the ISP to limit the number of public IP addresses used to the number of users actively connected through the ISP's host to the Internet. The end-user equipment will implement a second protocol stack, carrying PPPoE communications. The PPP protocol will allow the end-user equipment to obtain and utilize the public IP address for communications going to and from the public internetwork.

The switch **19** will limit transport of other types of PPPoE broadcast messages to the link to the PPPoE concentrator **31**, in a manner similar to that described above for the PPPoE address request. The switch **19** also limits transport of non-PPPoE broadcast messages to the vertical services domain network **131**, both for the address request message and for other types of broadcast requests. As such, the logical circuit to the PPPoE concentrator **31** becomes the conduit to one broadcast domain for upstream PPPoE mes-

sages; and the vertical services network **13** defines a second broadcast domain for upstream messages of other Ethertypes.

As noted, the end-user equipment **25** will implement two protocol stacks, a native stack without PPPoE and a second stack with PPPoE and a shim. In actual operation, both the native stack with other Ethernet protocols and the wide area stack with PPP and the PPPoE shim often will be active at the same time. The software in the data equipment **25** will utilize one stack or the other depending on whether the user selected a link, e.g. a URL, relating to the wide area internetwork or the vertical services domain. For example, a browser may display a page with embedded links. If a link is to a service on the vertical services domain, the embedded address will be a private address on the vertical services domain. Selection of such a link causes the device **25** to use the native Ethernet stack (without PPP or PPPoE) and the private address. Hence the L3/4 ATM switch **19** routes the request triggered by selection of the link to the vertical services domain **13**. In contrast, if the link is to a service on the public Internet or other network **11**, the embedded address will be a public IP address. Selection of such a link causes the end-user device **25** to use the PPP and PPPoE stack and the public address. Hence the L3/4 ATM switch **19** routes the request triggered by selection of the link over the virtual circuits to the PPPoE equipment **31** of the currently selected access provider network **11**.

Services provided on the vertical services domain therefore appear as simple IP data services, albeit using the appropriate address space. Virtually any communication service provider may access the vertical services network **13** and through it the carrier's local customer base simply by providing an IP interface for coupling appropriate equipment to the vertical services network. For example, it is a simple matter to connect a direct satellite broadcast receiver system, similar to those used today in residential applications, through an IP interface to provide the full range of received video services over the vertical services network **13**. This network may distribute the video programming to a number of L3/4 ATM switches **19**, within a local geographic area serviced by the ADN network **10**. The L3/4 ATM switch **19** co-located with the DSLAM **17** provides an optimum point for frame or cell replication for multicasting services.

For a multicast service, such as the satellite-originated video broadcast service, the service provider sends one stream through the vertical services domain network **13** to the L3/4 ATM switch **19**. The switch **19** will monitor every ATM virtual circuit going to the subscribers, looking for IGNP requests. A subscriber sends an IGNP request to join a selected multicast channel. When the L3/4 ATM switch **19** detects such a request, it identifies the requested channel and the requesting subscriber equipment and forwards a 'join' message to the vertical services domain. Subsequently, the switch **19** replicates received packets for the requested broadcast channel, and the switch drops the replicated packets into the cells for each of the virtual circuits of all of the joined subscribers, including the newly added subscriber. When the subscriber later elects to end viewing of the multicast, the subscriber's equipment sends a 'leave' message, and the switch **19** stops adding the cells for the multicast to that subscriber's virtual circuit.

In addition to vertical services, the carrier continues to provide agreed access services to the equipment of the ISPs, in a manner analogous to current practices. For example, the carrier may provide its Internet access service to a subscriber on a monthly subscription basis, at one of several available rates corresponding to the grade of internet access service (and thus the rate of communication to/from the ISP) selected by the customer's subscription.

In an enhanced service offering, the broadcast provider could offer a convenient navigation interface from a web server. The server could be on the vertical services network, but preferably is on the wide area Internet **11**. With a PPPoE session active, the user can surf to the provider's server and view information about available programming. The user might select a current broadcast program by 'clicking' on a URL link in the provider's web-based information. Although provided through the wide area Internet **11**, the URL would actually contain the private IP address for the desired broadcast program available from the vertical services network **13**. Selection of such a URL therefore would generate a message to the appropriate server on the vertical services network **11** to initiate the above discussed procedure to allow the user to 'join' the selected broadcast. A similar methodology might also enable a provider to offer menu, selection and order/billing services from the Internet **11**, to provide pay-per-view or video on-demand type services from the vertical services domain network **13**.

Although IP-based, the services from the vertical services domain **13** may follow any other desirable business model. For example, a multicast service provider may contract with the carrier to provide multicast audio (radio-like) and/or video (TV-like) services via the vertical services domain. The multicast service provider, not the subscribers, would pay the carrier. The multicast service provider may offer any or all of the multicast programming to customers on some type pay-per-view basis but would likely offer most of the programming service for free or bundled in as part of some nominal monthly subscription charge. The multicast service provider instead would charge advertisers in a manner analogous to current broadcast business practices. Advertising distributed with the IP multicasting, however, can be carefully targeted at end-customers having demographic profiles meeting specific criteria specified by individual advertisers, which allows the multicast service provider to charge premium advertising rates.

Table 2 summarizes the characteristics and requirements of a number of examples of the types of vertical services that the VSD network **13** can deliver via the L3/4 ATM switch **19** and the ADSL data network **10**.

TABLE 2

Vertical Service Offering	Characteristics of the Service	Network Requirements
Voice Services	Local Co-Located VoIP Gateways, VoIP, Unified messaging, IP PBX, IP Centrex	Low latency, low jitter, non-correlated packet loss, and high availability
Video On Demand (Unicast)	Local VOD Servers or access to centralized servers.	High bandwidth, low jitter, high availability, and low packet loss

TABLE 2-continued

Vertical Service Offering	Characteristics of the Service	Network Requirements
	Supports whatever model of server deployment/content delivery mechanism.	
Multimedia Broadcast (Multicast)	Broadcast Video; Broadcast Audio; Satellite Down Link support; Local Servers at the edge.	Varies with content type and with multicast implementation
Caching Services	Local servers at the insertion point, Local delivery mechanism for generic media objects such as web pages, images, video files, audio clips, software downloads, etc.	Layer ¾ visibility
Distance Learning (EVC)	Integrated interactive video, voice and data	Low latency, low jitter, non-correlated packet loss, and high availability
Telecommuting	Closed user group with access to Transparent LAN Service (TLS).	IEEE 802.1Q

The above discussed preferred embodiments implemented the processing above the layer-2 protocol in an enhanced ATM switch and focused on implementation over an xDSL network specifically designed for use of twisted pair wiring to the customer premises. Those skilled in the art, however, will recognize that the principles of the present invention are equally applicable to other types of layer-1 and layer-2 transport/switching technologies as well as selection based on other protocols above the layer-2 connectivity protocol. FIG. **5**, illustrates the implementation of the layer 3/4 and higher switch functionality in a generic access router (AR) **61**. The illustration also teaches the provision of digital subscriber line data communication between the access router (AR) **61** and a number of customer premises, using a variety of line technologies. The digital line technologies include dial-up modems **63**, **65** as well as wireless communications between wireless asymmetrical subscriber loop (WASL) transceivers **67**, **69**. The access router (AR) **61** can service residential customers via these other communication technologies as well as through the DSLAM **17** and the ATU-R **23** as in the earlier embodiment. The access router (AR) **61** also serves business customer router equipment **71**, using a variety of fast frame/cell packet technologies **73–76** and even optical fiber (SONET) **71**.

Those skilled in the art will recognize that even these examples are limited. For example, the invention may apply to pure video networks, such as in a hybrid fiber-coax implementation of a CATV system with digital video service as well as cable modem service.

The access router (AR) **61** will provide one or more types of logical circuits, implemented in the appropriate layer-2 protocol(s), e.g. ATM, frame relay, etc. Although the links to the wide area internetwork and the vertical services domain have been omitted here for simplicity of illustration, the access router (AR) **61** will provide the routing functions to and from the wide area internetwork and the vertical services domain in a manner similar to the functionality of the L3/4 ATM switch **19** in the earlier embodiment. In this regard, the access router (AR) **61** will support the QoS levels and will enable local insertion of vertical services.

FIG. **6** depicts a portion of the network of FIG. **5**, showing the interconnection thereof with the wide area internetwork and the local vertical services domain. The vertical services network itself may include a number of routers (R) **73**. Through that network, the access router (AR) **61** provides communications with services in the VSD that may be purely local, somewhat distributed or even centralized. True long distance data services, such as chat rooms, email and web browsing on the public Internet, however, are considered as Off-Net services, since they are accessed via the Internet access connection under the associated SLA.

Another feature of the present invention relates to a technique for customer-centric selection of telecommunications services and associated automated provisioning of the customer's data network services. The preferred embodiment of this feature of the invention utilizes a correlated information flow, in which the customer's MAC address has a corresponding, temporary IP address and a corresponding virtual circuit identifier (or VPI/VCI). A related aspect of invention encompasses software for implementing the automated provisioning of services through the access data network.

FIG. **7** is an enhanced block diagram of the access data network, showing certain additional elements involved in the automated selection and provisioning of customer services. FIG. **7** also is the first of several drawings showing an enhanced CPE device for use with the inventive ADN network. Elements of the network referenced by the same or similar numbers as shown in the earlier drawings are substantially the same as like numbered elements discussed above, for example relative to FIGS. **1** and **2**.

The provisioning methodology enables a customer that is capable of receiving vertical services to use a web-based software application to order service. The automated interaction of the user through the common web-based software application causes communications to software entities extant in one or more of the services domains, which coordinate the processes that will automatically provision the corresponding data circuit, according to both customer-selected parameters and detected network parameters. This service selection and provisioning technique significantly reduces, or completely removes, the errors present in the previous data circuit provisioning processes, such as: manual ordering processes; manual record-keeping; and manual circuit changes at the PSTN frame and the intermediate ADSL frame.

The network of FIG. **7** is arranged and provides services essentially as described above, except that certain servers are operated on the Internet or preferably within a privately controlled area or domain of the vertical services networking to enable the customer-selection of telecommunications services and the associated automated provisioning of the customer's data network services. For example, the illustrated embodiment shows a DHCP server **81** within the network services domain **33** (carrier's private portion associated with the vertical services domain through the node **18**). The carrier will also operate a web server **85** from the vertical services domain **13**, although this server could

operate from the public Internet. The carrier also operates one or more provisioning servers **87**, for example, via the network services domain **33**. The physical network of the vertical services domain **13** and the network services domain **33** may overlap or be substantially the same. The network services domain, for example, may comprise a private virtual network set up for the carrier's own network-operations through the same network as forms the vertical services domain.

The user will run a standard Internet browser application **83**, for example on a PC **25** or other appropriate data communication device. The web server **85** and the provisioning server **87** run one or more applications **91**, **93** and **95** related to the service selection and provisioning operations, as discussed in more detail below.

Certain communications, discussed layer, may be exchanged between the servers, **81**, **85** and **87**, for example via the node **18** and physical links of the domains **33** and **13**. The provisioning server **87** also communicates with the actual service transport elements of the access data network, such as the DSLAM **17**, the switch **19**, and the gateway router **29**, to conduct a metering operation and/or to activate and control provisioning of services through such elements. The links between the provisioning server **87** and these elements, shown by dot-dash lines in the drawing, may go through secure logical channels through the network services domain **33** and the node **18** or may use other private data communication links.

The preferred embodiment allows the user to select services via a standard web browser interface, that is to say using a browser application **83**. The browser application **83** communicates with a Service Application **91**. The carrier also utilizes two software modules, a Metering Application **93** and a Provisioning Application **95** in the presently preferred embodiment. The Service Application **91** and the Metering Application **93** may run as one or more programs on the web server **85**, the provisioning server **87** or some other server securely maintained by the carrier in one of the vertically inserted domains. For example, the Service Application **91** may run as one or more of the programs on the web server **85**; whereas the Metering Application **93** and the Provisioning Application **95** preferably run on one or more provisioning servers **87** in the network services domain **33**. Alternatively, the Metering Application **93** could run on one of the actual service transport elements of the access data network, such as the DSLAM **17** or the switch **19**.

Also shown in FIG. **7** are a modified CPE/ATU-R **22**, a browser application **82** running on the PC **26** connected to the CPE/ATU-R **22**, and a CPE programming application **92**. According to an embodiment more fully described later, the CPE/ATU-R **22** alters the data frames, if necessary, received from the PC **26** and other user devices at the premises before the data frames are forwarded to the DSLAM **17**. The browser application **82** interfaces with an application **92** on the web server **85** to facilitate programming of the CPE/ATU-R **22**.

The hardware of a server system, such as the server **85** or the server **87**, corresponds to that of a typical general-purpose computer, comprising a central processing unit (CPU) formed for example of one or more microprocessors, a number of memory devices and an interface to the data communication network, in this case to the IP network forming the respective domain **13** or **33**. Such a server computer may also provide a local or remote graphical user interface (GUI) for operation and control of the server by carrier personnel. Such an interface, for example, may comprise a common type of display, a keyboard and one or more of the common types of cursor controls. Various media, readable by such a computer system, may store or carry the executable code and any associated data for the respective Application, for example the web pages provided by the server **85** and/or the associated code of the Service Application **91**, for the Metering Application **93** or for the Provisioning Application **95**. Examples of such media include semiconductor and disk type memories, digital tapes, and the like. Computer readable media used by such systems also include various types of signals sent and received by computer systems for loading software code, associated data and/or web pages into the memory and/or the CPU of the respective server system hardware.

FIG. **8** shows the actors, activities, and attendant messages involved in this exemplary method. Each activity resides in the domain of a particular actor: the customer domain **800**, the carrier/PSTN domain **810**, or the service domain **820**.

With reference to FIGS. **7** and **8**, the method begins when the customer contacts the carrier and requests ADSL service (step **801**). The carrier connects the ADSL circuit (step **811**), which entails moving the customer's POTS circuit to the ADSL frame at the remote terminal or central office, and cross-connecting back to the switch frame.

In step **802**, after receiving and setting up the ADSL equipment and concomitant software, the customer starts an IP session over the ADSL line. In doing so, the customer's PC **25** (acting as a DHCP client) automatically requests and negotiates an IP address (step **8211**) and other operational parameters with a DHCP server **81** in the network services domain **33**. This IP address obtained in step **8211** is temporary, as it is used solely for the purpose of establishing a session. Later, the customer will receive a permanent or session IP address from its ISP/Global Service Provider (GSP) **11'**.

In step **803**, the customer uses the Web browser application **83** to access one or more of the network service provider's service pages via the PC **25**, for example, from the web server **85** on the vertical services domain **13**. In order to avail the customer of the services and GSPs **11'** that will work acceptably well on the customer's particular ADSL line **21**, the Service Application **91**, determines the available services by acquiring a bandwidth metric (e.g. packet rate) from the Metering Application **93** (step **822**). As shown in steps **823** and **804**, the Metering Application **93** employs an interactive method for determining the maximum data rate. This rate determining method may be based on a dampened oscillation algorithm, and may employ the mechanisms inherent to TCP. In the preferred embodiment, the Metering Application **93** should be in the core of the service domain **13** or **33** so as to measure the TCP/IP packet rate between the subscriber equipment and the respective services domain. However, other metering application techniques may be used from the same or other locations.

In step **824**, the Service Application **91** sends a Web page to the customer, populated with the available services and identifications of the GSPs. In step **805**, the customer selects services and one (1) primary GSP. Step **824** involves a determination of the customer's data rate, which will be the lower of the metered rate and a rate based on the customer-selected services.

In step **825**, the Service Application **91** receives the customer's selections, and requests the data circuit by sending customer's IP address and data rate. In step **826**, the Provisioning Application **95** obtains the customer's MAC address from the DHCP server **81**.

In step **827**, the Provisioning Application establishes communications with the vertical services insertion (VSI) ATM switch **19**, and may use a script or other remote mechanism to either request the appropriate data circuit, or set up the data circuit (**8121**). The data circuit will have an association with the customer's MAC address, and will have a provisioned peak rate no less than that initially determined by the Service Application **91**.

In step **828**, the Provisioning Application **95** receives the logical circuit information (or VCI/VPI) for the customer, and subsequently communicates with the gateway router **29** to set up the appropriate logical circuit (or VPI/VCI) for the customer (step **8131**). In step **813**, the gateway router **29** may set up the circuit in response to a request from the Provisioning Application, or may be controlled by the Provisioning Application. The Provisioning Application **95** may similarly communicate with the switch **19** or the DSLAM **17**, as appropriate, to provision the customer circuit. Thus, the customer has a PVC that traverses the exemplary ADSL data network, and this PVC was set up using the automated method presented here.

Certain aspects of the invention relate to the software elements, such as the combination of the Service Application **91**, the Metering Application **93** and the Provisioning Application **95**, shown in FIG. **7**. Other aspects of the invention relate to software elements of the CPE device **22**, as discussed more below. At different times all or portions of the executable code for any or all of these elements may reside in physical media or be carried by electromagnetic media. Physical media include the memory of the server(s) **85**, **87**, or the CPE device **22** such as various semiconductor memories, tape drives, disc drives and the like of general-purpose computer systems. All or portions of the software may at times be communicated through various networks, for example to load the software from another computer into the respective CPE device or server, or into another network element. Thus, another type of media that may bear the software includes optical, electrical and electromagnetic waves, such as used across physical interfaces between local devices, through wired and optical landline networks and over various air-links.

In the ADN depicted in FIG. **2**, a customer's PC **25** was described that utilizes one or more protocol stacks to encapsulate IP datagrams, or other higher level data, in an Ethernet frame using an appropriate Ethernet type. In particular, the PC **25** included a protocol stack with a PPPoE shim that encapsulates and decapsulates data between a PPP layer and an Ethernet layer of the protocol stack. The resulting PPPoE Ethernet frames as well as other ethertype frames are exchanged between the PC **25** and an ATU-R **23** to communicate with the carrier's network.

With the different protocol stacks residing on the PC **25**, customers could unintentionally disable PPPoE functions during routine configuring of the PC **25**, performing operating system upgrades, or installing additional software applications. Also, in the embodiment of FIG. **2**, each device is responsible for providing an appropriate PPPoE shim in order for that device to communicate, through the ADN, with remote Internet sites. While conventional PCs can easily include such functionality, other intelligent devices such as toasters, IP phones, climate systems and security systems do not necessarily include PPPoE shim functionality.

An alternative embodiment of the present invention is now described that addresses some of the concerns that can arise from placing the PPPoE shim functionality on the PC **25**. In this alternative embodiment, depicted in FIG. **9**, VSI customer premises equipment (CPE) **902** is coupled with the ATU-R **904** to provide some of the Ethernet encapsulating function previously performed by the PC **25**. FIG. **9** illustrates the CPE **902** and the ATU-R **904** as a logical unit; these logical units, however, can be combined in various equivalent physical arrangements. For example, the ATU-R can include upgradeable firmware that can be augmented to permit the ATU-R **904**, in addition to its conventional functions, to provide the functions of the CPE **902**. The CPE **902** can be a stand-alone hardware piece located between the home network **906** and the ATU-R **904**. The CPE **902** can also be a hardware apparatus that physically connects to interfaces on the ATU-R **904** or, depending on the modularity of the ATU-R **904**, the CPE **902** could be a plug-in module that connects to a chassis or bus of the ATU-R **904**.

In operation, devices 901_1–901_4, connected over a home LAN **906**, communicate with the CPE **902** via conventional Ethernet, or other data-link layer, frames. While native Ethernet devices 901_1–901_4 are preferred, devices configured for other network types, such as HPNA, can be used along with a frame translator that bridges signals between Ethernet and the other network type. The Ethernet, or other data-link layer, frames received by the CPE **902** have IP, or other network-layer, datagrams, with a destination address and other higher layer information, encapsulated within. In response to receiving Ethernet, or other data-link layer, frames from the network **906**, the CPE **902** generates Ethernet, or other data-link layer, frames that are then encapsulated in ATM cells according to the underlying Layer 2 architecture of the ADN and forwarded via the DSL link **908** to a VSI device **910**. As described earlier, the VSI device routes the Ethernet, or other data-link layer, frames according to the type identifier (e.g., ethertype) within the frames to a vertical service domain locally connected to the VSI device **910** or to the Internet via a gateway router **912**.

In generating, for example, Ethernet frames, the CPE **902** examines upper layer information within the frame received via the home LAN **906** and determines the appropriate ethertype encapsulation according to the service on the ADN to which that Ethernet frame is destined. The CPE **902** then generates an Ethernet frame according to the appropriate ethertype just determined. This generated Ethernet, or data-link layer, frame is forwarded over the ADN according to the underlying layer 2 architecture (also a data-link layer) of the ADN. In this manner, each device 901_1–901_4 need only include conventional Ethernet based protocol stacks, with the CPE **902** providing the shim software to alter data-link layer frames. Thus, the PPPoE shim software, in the Ethernet example, is protected from misconfiguration and damage caused by a customer's activities.

The table **920** illustrates one exemplary scheme for the CPE **902** to determine the appropriate ethertype encapsulation for a received frame. The table **920** depicts a modified version of a routing table which is typically found (in unmodified form) in devices with TCP/IP protocol stacks communicating over Ethernet networks. Each row of the table **920** is an entry for a particular destination IP network. The left-most column **922** identifies the network or domain to which a particular table entry applies. The middle column **924** identifies a subnet mask that is typically used to specify how many bits of an IP address to use when searching for a matching table entry. The right-most column **926** identifies the ethertype appropriate for a particular table entry (i.e., IP network). The first entry (network 0.0.0.0) is typically considered the default route; this means that if an explicitly matching entry is not found in the table **920** then this default

entry is used. As shown, the default ethertype is PPPoE which, according to one VSI embodiment described herein, denotes Ethernet frames ultimately destined for the Internet. The next two entries identify private IP networks, such as those used in the central office to provide inserted vertical services, local network services and/or VLAN services. As shown, Ethernet frames destined for the networks providing the various local or vertical services are encapsulated in an Ethertype other than PPPoE. The VSI device **910** is able to route the frames appropriately based on the frames' ethertypes.

The table **920** is exemplary in nature and is not intended to limit the scope of what upper layer information can be used to determine the appropriate encapsulation ethertype. Information from the transport layer, or even the application layer, could be used by the CPE **902** for ethertype determinations.

FIG. **10** illustrates a schematic hardware view of a CPE/ATU-R device **1000** according to an embodiment of the present invention. The circuitry for performing the conventional functions of an ATU-R or a router are not illustrated in the apparatus of FIG. **10** as these functions are not critical to an understanding of the innovative aspects of the CPE **1000**. For example, the SAR circuitry for exchanging ATM cells to and from the upstream side of the ATU-R is not shown. Similarly, the circuitry for examining a downstream packet to determine which Ethernet port interface to forward the packet to is not shown in detail.

LAN interface ports 1002_1–1002_4 communicate with devices on a home (i.e., customer location) network preferably using conventional Ethernet frames that encapsulate higher layer data. Ethernet frames received via the interfaces 1002_1–1002_4 are forwarded to the router, or multiplexer, circuitry **1004**. A processor **1010**, or other equivalent circuitry, then examines the higher layer data encapsulated within the Ethernet frame to determine an intended network destination. From the intended destination, a matching table entry, from a table **1014** stored in the memory **1012**, is identified. Based on the identified table entry, the Ethernet frame is encapsulated according to one of a variety of ethertypes. The encapsulation according to the different ethertypes performed by the CPE device **1000** can range from being as complex as restructuring the entire frame and its header to as simple as altering, or setting, a multi-bit "type indicator" field within the frame's header. The appropriately encapsulated Ethernet frame is then forwarded out the ATU-R **1008**. Buffer **1006** is shown as a part of the router circuitry **1004** in consideration that encapsulation and unencapsulation of Ethernet frames takes a finite period of time in which other frames can be received. As well understood in network switches, the buffer **1006** prevents the loss of data during the processing of incoming and outgoing Ethernet frames.

With respect to downstream traffic, the CPE **1000** can detect the ethertype of a received frame without reference to a routing table and therefore can automatically translate between the incoming ethertype and the conventional ethertype used by the home LAN. However, the router **1004** does function to determine the appropriate interface 1002_1–1002_4 to forward a frame to based on which interface 1002_1–1002_4 the downstream destination device is connected to. Accordingly, the CPE device **1000** can perform session proxy functions such as network address translations and other routing procedures.

FIG. **11** depicts a more logic-level view of the CPE/ATU-R device described in relation to FIG. **10**. The different ethertypes can be thought of as logical ports. Analogous to a typical network switch, an incoming frame is analyzed by the CPU that implements a switching function to determine the appropriate outgoing interface. Instead of multiple physical output interface ports being the possible destinations, logical ports **1102**, **1104** and **1106** are the possible output destinations to select from. Each of these logical ports represents different level 2 encapsulation software of a protocol stack, or stacks. In operation, the CPU **1110** analyzes upper layer information within a received Ethernet frame to determine which logical port **1102**–**1106** to forward the frame to. The CPU **1110** consults data **1112** in a memory **1114** in determining the appropriate logical port. As a result of being forwarded to the different logical ports, different Ethernet frames are encapsulated as different ethertypes. Within the VSI environment, therefore, the different frames can be routed to either vertical services or conventional Internet-based services domains based on their ethertypes.

In addition to the benefits previously mentioned, the placement of the PPPoE shim functionality out on the CPE device provides a number of other advantages.

Security of the home network can be enhanced utilizing the CPE with the PPPoE shim functionality. Most routers have firewalling capabilities that are typically implemented via an access control list (ACL) mechanism. The table **930** illustrates an exemplary security table that has entries corresponding to MAC addresses of the devices 901_1–901_4 on the home network **906**. Each entry includes a MAC address and a corresponding rule. While the precise syntax of the rules differs among different vendors, the rules typically specify what destination and origination equipment can communicate with a particular MAC address. According to one aspect of the present invention, the ACL rules can be extended to identify what types of ethertype encapsulation are allowed for the different devices 901_1–901_4 of the LAN **906**. For example, a PC will likely communicate with the vertical services domain as well as the Internet, but a home security system probably will only communicate with the vertical services domain. Accordingly, a security table entry can be created to prevent PPPoE (i.e., Internet) sessions from being started by, or received by, the security system. When processing frames, the CPE will check not only the routing table to determine the appropriate ethertype encapsulation but will also refer to the ACL to determine whether or not to process the frame at all.

In addition, having a protocol stack with a PPPoE shim located at the CPE **902**, allows the CPE **902** to function as a PPPoE proxy, if desired. In a proxy arrangement, the CPE initiates a PPPoE connection to an ISP similar to the manner described earlier in conjunction with a customer's PC establishing a PPPoE link. Thus, the CPE **902** is allocated a public IP address. The different devices 901_1–910_4 communicate with the CPE **902** via standard Ethernet frames which the CPE **902** encapsulates and multiplexes over the PPPoE connection (assuming the frames are destined for the Internet). Return PPPoE frames are addressed to the CPE **902** which, using conventional network address translation (NAT) methodology, demultiplexes the received return frames to the appropriate devices 901_1–910_4. This proxy functionality provides the ability to share a single PPPoE link among multiple home devices 901_1–901_4 and improves security by preventing direct communication with the devices 901_1–910_4. Of course, the PPPoE proxy arrangement is optional. Devices 901_1–910_4 can also independently establish their own PPPoE links so that each of them has a separate IP address and PPPoE session.

One of the significant benefits of the CPE and ATU-R equipment depicted in FIG. **9** is that upstream quality of service (QoS) can be provided. Implementing downstream QoS has been described in detail with regard to the VSI switch. A similar methodology can be utilized with regards to the upstream data. The CPE can determine the physical upstream rate of different traffic types and then prioritize and queue traffic according to predetermined traffic types. As described with regard to the VSI switch (FIG. **2**, element **19**), the CPE can examine each communication and determine an appropriate tag to add to an outgoing cell as part of its internal processing. Using the tags, the CPE will place each of the cells into one of a plurality of queues similar to those discussed above relative to QoS operations of the VSI switch. Thus, the order and rate at which different ethertype frames are forwarded out the ATU-R can be controlled to support QoS for various services between the customer and the carrier.

Generation and downloading of the programming information for the CPE/ATU-R **1100** can be accomplished manually via one of the customer devices connected to an Ethernet port 1002_1–1002_4. An embedded web server or similar application could be provided in the memory **1114** that communicates with the connected customer device to allow a customer to manually generate programming information such as the routing tables, ACL tables and QoS parameters. The CPE/ATU-R **1100** could also be similarly programmed via devices connected to it through the ATU-R interface **1008**. In an embodiment described more fully later, the programming information is automatically generated and downloaded to the CPE/ATU-R **1100** via software extant in the local access network domain.

FIG. **12** provides a flowchart that summarizes the steps taken by the CPE in forwarding Ethernet frames to the ADN. In step **1202**, an Ethernet frame is received at one of the interface ports. The Ethernet frame encapsulates datagrams. Information related to an upper-layer protocol is extracted, in step **1204**, from the received frame. Examples of such information include the destination IP address encapsulated within the Ethernet frame. A set of rules (e.g., a routing table) is consulted to determine, in step **1206**, what ethertype encapsulation needs to be used based on the extracted upper-layer information. Once the ethertype encapsulation method is identified, the datagram is re-encapsulated, in step **1208**, using the identified ethertype encapsulation method. Once encapsulated, the frame, in step **1210**, is forwarded upstream over the ADN. In performing the forwarding step (step **1210**) the CPE can also consult security access control lists to identify permissible connections and sessions and block Ethernet frames when appropriate. Similarly, the CPE can also perform the forwarding step in a manner to ensure conformance with any QoS parameters associated with the upstream bandwidth.

Trained network personnel perform the complex configuration of the parameters that control the QoS functions for the downstream data of the ADN; a typical customer, however, does not have the knowledge to properly configure upstream QoS parameters. In a related point, many customer's would find it extremely difficult, if not impossible, to correctly generate ACLs, NAT information, and routing tables. One further aspect, therefore, of the architecture depicted in FIG. **9** is the capability for automatically programming the CPE based on the services a customer orders. In a preferred embodiment, the automatic programming of the CPE relies on some of the automatic provisioning software and services depicted and described in relation to FIG. **7**.

The methodology relating to automatic programming of the CPE enables a customer to use a web-based software application to program the CPE. The automated interaction of a user through a web-based software application causes communications to software entities extant in one or more service domains, which coordinate the processes that will automatically configure the CPE according to both customer selected parameters and other network parameters.

Referring to FIG. **7**, the user will run a standard Internet browser application **82**, for example on a PC **26** or other appropriate data communication device. The web server **85** and the provisioning server **87** run one or more applications related to services selection **91** and CPE programming operations **92**. Through the web interface, the user will select services that are appropriate for the devices **26** connected to the CPE/ATU-R **21**. Through communication between the provisioning server **87** and other elements of the ADN, the provisioning server **87** and web server **85** will identify ethertype and corresponding network address information useful in populating a routing table such as that depicted in Table **920**.

Based on the suite of services selected by a user, the provisioning server **87** and web-server **85**, through coordinated processes **91**, **92**, **93** and **95**, can also determine optimal queuing and prioritizing parameters to enable implementation of upstream QoS. The optimal queuing can be partly based on the experience and knowledge of network personnel; thus relieving the user from attempting such a difficult task.

Access to a web-based application **92** can be provided through the web-server **85** that will guide a user through the process of identifying network devices and services and in defining related security parameters, such as table **930**. Preferably, this application communicates with other software elements, already described, regarding the services offered to and selected by the user so that the user is intelligently presented relevant options and alternatives while creating a security profile for use in the CPE **22**. In FIG. **7**, the web server **85** is depicted as running both the CPE Programming Application **92** and the Service Application **91**; one skilled in the art would recognize that these two application can also be run on separate servers.

Ultimately, the security profile, the QoS parameters and the ethertype routing table will be downloaded via the ADN to the CPE **22** in order to automatically program the device. In one embodiment, a default configuration or a simple web-based interface is provided with the CPE **22** to perform the initial communications needed to initiate the communication session needed to perform a full programming of the device.

FIG. **13** depicts the logical flow of the software processes extant in the ADN that provide automatic programming of the CPE. A user, preferably via a web browser, connects (step **1302**) to a web-server front end that coordinates the gathering of data needed to program the CPE. From web pages served (step **1304**) by the front-end, the user can direct the gathering of relevant information. In particular, information relating to the services used by the customer, the devices present at the customer's location and the security preferences of the user must all be gathered (steps **1306**, **1308** and **1310**). The information does not necessarily have to be manually entered by the customer. Through other communication paths in the ADN the web server can identify those services subscribed to by a customer as well the upstream network bandwidth requirements of those services. Similarly, the CPE and the customer device's are connected

via the home network. Using such a connection MAC addresses and information regarding the devices can be gathered by the CPE and automatically passed to the web server front-end. Using the gathered information, a graphical, or other intuitive interface, can be presented to the customer to aid with the selection of meaningful and appropriate security Access Control Lists (ACL). Once all the information is gathered, the web server can generate, or access a back-end application that can generate, data formatted in a manner that can automatically program the CPE. Exemplary data that can be generated are the rule-sets that permit prioritizing and queuing to meet QoS constraints (step **1312**), routing tables that associate a particular encapsulation method with network destination information extracted from a received frame (step **1314**), and security tables that specify permissible communication target addresses, source addresses and session encapsulation types (step **1316**). Once appropriately formatted data is generated, this data can be forwarded through the ADN of this particular user (step **1318**). Upon receipt of the programming data at the CPE, the behavioral characteristics and parameters of the CPE are modified according to the downloaded programming (step **1320**).

While the foregoing has described what are considered to be the best mode and/or other preferred embodiments of the invention, it is understood that various modifications may be made therein and that the invention may be implemented in various forms and embodiments, and that it may be applied in numerous applications, only some of which have been described herein. It is intended by the following claims to claim any and all modifications and variations that fall within the true scope of the inventive concepts.

What is claimed is:

1. A Customer Premises Equipment located between an access data network, providing access services to at least two network domains, and one or more customer devices that utilize services provided over the access data network, comprising:

a first interface for receiving a first frame from the one or more customer devices;

a second interface for forwarding a second frame upstream to the access data network, said second frame encapsulated according to a selected one of a plurality of encapsulation methods;

a decision table for storing a correlation between each of a plurality of upper-layer network data and a respective encapsulation method;

a circuit configured to:

extract upper-layer network data from the first frame;

identify a table entry corresponding to the extracted upper-layer network data; and

determine the selected one encapsulation method associated with the identified table entry; and

a protocol stack for encapsulating data within the first frame into the second frame according to the selected one encapsulation.

2. The Customer Premises Equipment according to claim **1**, wherein the circuit comprises a switch and the first interface includes a plurality of interface ports coupled to the switch for communicating with the one or more customer devices.

3. The Customer Premises Equipment according to claim **1**, wherein the circuit comprises a router and the first interface includes a plurality of interface ports coupled to the router for communicating with the one or more customer devices.

4. The Customer Premises Equipment according to claim **1**, wherein the protocol stack is configured to generate said second frame by modifying a type-identifier field within a header of said first frame if necessary to conform to the selected one encapsulation method.

5. The Customer Premises Equipment according to claim **4**, wherein the type identifier field identifies one of a plurality of different ethertypes.

6. The Customer Premises Equipment according to claim **1**, further comprising:

a DSL modem coupled between the second interface and the access data network.

7. A Customer Premises Equipment located between an access data network, providing access services to at least two network domains, and one or more customer devices that utilize service provided over the access data network, comprising:

a first interface for receiving a first frame from the one or more customer devices, said first frame comprising a payload and a first header;

a second interface for forwarding a second frame upstream to the access data network, said second frame comprising the payload and a second header;

a decision table for specifying a correlation between each of a plurality of types of upper-layer network data and a respective frame-type identifier;

a circuit configured to:

extract upper-layer network data from the first frame;

identify a decision table entry corresponding to the extract network data; and

determine a selected one frame-type associated with the identified table entry; and

a protocol stack for generating the second header by modifying the first header, if necessary, according to the selected one frame-type.

8. A method for providing upstream data frames from a Customer Premises Equipment, comprising the steps of:

the Customer Premises Equipment receiving, from a customer device that utilizes services over an access data network that provides access services to at least two network domains, a first data-link layer frame containing encapsulated data;

using the Customer Premises Equipment to:

extract network services information from the encapsulated data, said network services information originating in a protocol layer higher than the data-link layer;

identify a selected one of a plurality of data-link layer encapsulation methods based on the extracted network services information;

modify the encapsulated data by encapsulating it into a second data-link layer frame according to the selected one data-link layer encapsulation method; and

forward the second data-link layer frame upstream via the access data network;

wherein the Customer Premises Equipment is located between the access data network and the customer device, and the forwarding step comprises assigning a priority to the second data-link layer frame based on a network service associated with the data encapsulated into the second data-link layer frame.

9. The method according to claim **8**, wherein the step of modifying consists essentially of modifying a value of a type-identifier in a header of said first data-link layer frame.

10. The method according to claim **9**, wherein the type-identifier specifies one of a plurality of ethertypes.

11. The method according to claim 8, further comprising the step of:

queuing the second data frame in one of a plurality of queues based on the assigned priority.

12. The method according to claim 8, wherein the step of forwarding the second data frame is performed according to QoS guidelines associated with the data encapsulated into the second data-link layer frame.

13. The method according to claim 8, wherein the extracted network services information comprises a layer 3 destination network address.

14. The method according to claim 8, further comprising the steps of:

receiving a downstream third data-link layer frame from the access data network containing encapsulated data;

encapsulating the encapsulated data of the third data-link layer frame into a fourth data-link layer frame according to an encapsulation method compatible with the customer device; and

forwarding the fourth data-link layer frame downstream to the customer device.

15. The method according to claim 8, further comprising the steps of:

receiving a downstream third data-link layer frame from the access data network containing encapsulated data;

identifying one of a plurality of customer devices for receiving the encapsulated data of the third data-link layer frame;

forwarding the encapsulated data of the third data-link layer frame to the identified one customer device.

16. The method according to claim 8, further comprising the steps of:

determining if the customer device has authority to participate in a communication session with a destination associated with the data encapsulated within the first data-link layer frame; and

performing the modifying step and the forwarding step only if the customer device is determined to have the authority to participate in a communication session with the destination.

17. The method according to claim 16, wherein the step of determining if the customer device has authority includes the steps of:

identifying a MAC address associated with the customer device;

identifying authorized encapsulation methods associated with the identified MAC address; and

granting authorization if the authorized encapsulation methods include the selected one encapsulation method.

18. A computer readable medium bearing instructions for providing upstream data frames from a Customer Premises Equipment, said instructions being arranged to cause one or more processors of the Customer Premises Equipment upon execution thereof to perform the steps of:

the Customer Premises Equipment receiving, from a customer device that utilizes services over an access data network that provides access services to at least two network domains, a first data-link layer frame containing encapsulated data;

using the Customer Premises Equipment to:

extract network services information from the encapsulated data, said network services information originating in a protocol layer higher than the data-link layer;

identify a selected one of a plurality of data-link layer encapsulation methods based on the extracted network services information;

modify the encapsulated data by encapsulating it into a second data-link layer frame according to the selected one data-link layer encapsulation method; and

forward the second data-link layer frame upstream via the access data network;

wherein the Customer Premises Equipment is located between the access data network and the customer device, and the forwarding step comprises assigning a priority to the second data-link layer frame based on a network service associated with the data encapsulated into the second data-link layer frame.

19. The computer readable medium according to claim 18, wherein the step of modifying consists essentially of modifying a value of a type-identifier in a header of said first data-link layer frame.

20. The computer readable medium according to claim 19, wherein the type-identifier specifies one of a plurality of ethertypes.

21. The computer readable medium according to claim 18, wherein said instructions being further arranged to cause the one or more processors of the Customer Premises Equipment upon execution thereof to perform the additional steps of:

queuing the second data-link layer frame in one of a plurality of queues based on the assigned priority.

22. The computer readable medium according to claim 18, wherein the step of forwarding the second data-link layer frame is performed according to QoS guidelines associated with the data encapsulated into the second data-link layer frame.

23. A method for providing upstream data frames from a Customer Premises Equipment, comprising the steps of:

the Customer Premises Equipment receiving from a customer device that utilizes services over an access data network that provides access services to at least two network domains, a first Ethernet frame containing an IP datagram;

using the Customer Premises Equipment to:

extract an IP destination address from the IP datagram;

forward, if the extracted IP destination address corresponds to an address in a vertical services domain, the IP datagram to the access data network in an Ethernet frame identified by a first ethertype; and

forward, if the extracted IP destination address corresponds to an address in an Internet domain, the IP datagram to the access data network in an Ethernet frame identified by a second ethertype, different from the first ethertype;

wherein the Customer Premises Equipment is located between the access data network and the customer device and the forwarding steps comprise assigning a priority to the Ethernet frame identified by the first ethertype or the second ethertype based on a network service associated with data in the Ethernet frame identified by the first ethertype or the second ethertype.

24. The method according to claim 23, further comprising the step of:

verifying that an entry in a security table authorizes forwarding the IP datagram to the access data network.

25. The method according to claim 23, wherein the second ethertype is point-to-point protocol over Ethernet.

26. The method according to claim 25, further comprising the step of:

establishing a single PPPoE session between the Customer Premises Equipment and a service provider in the Internet domain.

27. The method according to claim 26, wherein any Ethernet frames forwarded to the access data network are forwarded upstream over the single PPPoE session.

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